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INSTITUTION North Carolina State Dept. of Community Colleges, Raleigh.

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ABSTRACT

Twenty-five lesson plans for a third-year electrical apprentice technical training program are presented in this instructor's manual. Also included are student worksheets and information sheets for each lesson, and copies of unit tests. (Answers to the worksheets and tests are provided.) The lesson plans are generally organized into four steps: introducing the lesson, presenting the lesson (e.g., demonstration), student application (use of worksheets), and checking and follow-up (checking answers to worksheets). Some of the lesson topics are alternating currents, power factor correction, class III installations, gasoline dispensing and service stations, fundamentals of motor control, and estimating job costs. (Student worksheets and information sheets for this training program are also available separately--CE 018 358. Other related documents are CE 018 350-360 and include a basic mathematics review, jobsite supervisor's manual, and instructor's manuals and worksheets for the other three years of the program.) (JH)

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ED160882

INSTRUCTOR'S MANUAL
FOR
ELECTRICAL APPRENTICE
TECHNICAL TRAINING

SERIES No. C
(Third Year)

Revised to meet 1978 Electrical Code

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
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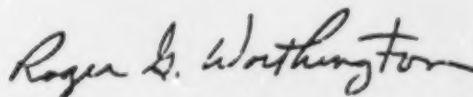
CE 018 357

An Equal Rights Note: Wherever, in this manual "man," "men" or their related pronouns may appear, either as words or as parts of words (and other than with obvious reference to named male individuals), they have been used for literary purposes and are meant in their generic sense (i.e., to include all humankind-both female and male sexes).

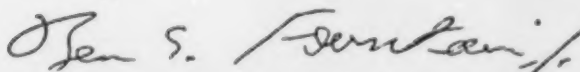
FOREWORD

The apprenticeship programs offered in North Carolina are important phases of the total educational program for industry in the state. The program of education for modern apprenticeship includes two distinct phases. The first phase is "on-the-job training." The student is employed by a firm in which duties are specifically assigned to enhance ones learning in the field of study. These experiences are planned and supervised so that the individuals will progress through the apprenticeship phase to that of the journeyman. The second phase of the program of education is termed "related instruction." In this phase the apprentice is provided the technical and theoretical foundation subjects that help one to learn the trade thoroughly and accurately. This portion is usually taught through evening school, but in some cases may be done through correspondence courses.

The North Carolina Department of Community Colleges, through the Program Development Section, has the responsibility for developing and making available the instructional materials that provide the learner with a sound educational program which is effective and appropriate to the method in which the materials are being utilized. The department has available these materials for the students, as well as support material for the instructor who teaches or who acts as counselor in conducting the related classes.



Roger G. Worthington, Director
Program Development



Ben E. Fountain, Jr., State President
Department of Community Colleges

PREFACE

The Program Development Section of the Department of Community Colleges has the responsibility for making available the related instructional materials required for use in occupational programs offered by the various institutions. This responsibility is accomplished by working with advisory committees and consultants representing each of the occupations in determining the needs and in developing the materials required to meet these needs.

These information sheets and worksheets have been prepared to provide specific assignments for studying related topics necessary in the training of electrical apprentices. An effort was made to develop the schedule to follow as the apprentice progresses with training. It will also enable the apprentice to know what skills and knowledges will be required. The objective of this program is to aid the instructor and employer in providing experiences necessary to develop not only a competent worker in the electrical field, but also, a well-rounded citizen.

This workbook includes assignment sheets and information sheets for the electrical apprentice to use in searching out related information. The worksheets contain problems to solve, questions to answer, diagrams to draw, and blueprints to consult. The apprentice should study the references (assigned by the instructor) before attempting to answer the questions or solve the problems.

In actual use of these lessons, instructors should feel free to modify their application of the material to conform with local needs. For example, there may be certain sections of the Code to teach because the apprentices are working with special installations. Thus, the instructor should lead a discussion on materials that applies to these situations. In other classes, the instructor may need to spend more time with the students on topics dealing with mathematics than with blueprint reading. In any event, the minimum class time for related material is 144 hours per year. It is sincerely hoped that the assignment sheets are used correctly so that apprentices can gain maximum benefits from their related studies.

ELECTRICAL APPRENTICESHIP TECHNICAL TRAINING

ACKNOWLEDGMENTS

Questions and problems for the Lesson Topics were prepared in July, 1964 by:

W.F. Humbert, III, Electrical Engineer
Winston-Salem, North Carolina

The Instructor's Manuals, Information and Orientation Sheets were developed by:

Howard E. Hedinger, Educational Consultant
Department of Community Colleges
Raleigh, North Carolina

The manual was revised in 1967, 1971, and 1975.

REVISION COMMITTEE 1978

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Mr. F. Lloyd Willard, Electrical Inspector High Point, North Carolina
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Raleigh, North Carolina

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*Note # 1: Page Numbers Listed
*Note # 2: Article Numbers Listed

*Note # 3: Division and Section Numbers Listed
*Note # 4: Chapter and Page Numbers Listed
*Note # 5: Basic Math References in left column
are 2nd Edition; Basic Math Ref. in
last column are 3rd Edition, 1972.

(Continued)
ASSIGNMENT
NAME (TITLE)

LESSON
NO.

BASIC
MATH

BASIC
ELECTRICITY

1978
N.E.
CODE

AMERICAN
ELECTRICIAN'S
HANDBOOK

MOTOR
CONTROL
FUNDAMENTALS

OTHER
MATERIALS

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(Continued) ASSIGNMENT NAME (TITLE)	LESSON NO.	BASIC MATH	BASIC ELECTRICITY	1978 N. E. CODE	AMERICAN ELECTRICIAN'S HANDBOOK	MOTOR CONTROL FUNDAMENTALS	OTHER MATERIALS
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Control Components	C-20			430		33-70	Motor Control Booklets
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(Continued) ASSIGNMENT NAME (TITLE)	LESSON NO.	BASIC MATH	BASIC ELECTRICITY	1978 N.E. CODE	AMERICAN ELECTRICIAN'S HANDBOOK	MOTOR CONTROL FUNDAMENTALS	OTHER MATERIALS
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Estimating	C-25						

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ELECTRICAL APPRENTICE TECHNICAL TRAINING
(GUIDELINES)

TO THE INSTRUCTOR:

- It is suggested that the instructor use an Orientation Sheet to help him become acquainted with the new apprentices. Name, address, birth-place, education, employers, and type of work, sponsoring employer, home situation (marital status and number of children), hobbies, likes and dislikes, etc., should be included.
- The Instructor's Manual and the Assignment Sheets or Worksheets have been revised to update the materials. Lessons are arranged in topics to reflect electrical installation in compliance to the N.E. Code.
- The brief Lesson Plans should act as a guide in conducting classes and in organizing the program. It is recommended that you write out your own plans, using illustrations that are familiar and timely.
- The Information Sheets and Worksheets are designed to help the apprentice master the related technical materials found in textbooks and references. The answer sheets are included in the Instructor's Manual.
- The third year (Series C) of the course in Technical Training for Electrical Apprentices is designed, as was the first two years, to make it easier for the instructor. The lesson outlines should help the instructor lead his classes gradually into the more complex phases of the study of Electrical Installation as required by the National Electrical Code.
- It should be noted by the instructor that:
 1. Topics on basic mathematical principles were reviewed and other applied topics were introduced during the first year (Series A). The second, third, and fourth year series contain no topics specifically on mathematical subjects. Yet the instructor will realize that additional practice in handling equations will be necessary for most apprentices by the time they begin to study alternating current. It will be essential for the instructor to pay special attention to these mathematical tools in order to be sure that the electrical theory will be completely understandable to the apprentices.

In the event that some of the apprentices are weak in mathematics, the instructor should make additional assignments in math problems using the Learning Resource facilities at the institution or give special individual help.

2. In this course, the topics on the National Electrical Code will be studied in terms of wiring methods. It is hoped that by studying the Code along with other subjects each year will help create interest and will be better applied to job situations.
3. There is a suggested list of audiovisual aids; however, the instructor should use any other aids available, but be sure to order them in ample time. It is hoped that the instructors will not have too much difficulty obtaining particular aids at the time they need them.

NOTE: A new list of audiovisual aids is being prepared.

- In the event the instructor uses individualized self-pacing methods where the students work at their own pace, he may need more programmed materials. Consult the Learning Lab for help in such case.
- Assignments and page references have been placed on a sheet following the Table of Contents. This sheet can be revised easier than all the lesson sheets when textbooks are changed. It is suggested that the references be written on the chalkboard for each assignment.
- Each apprentice or student should have a large three-ring notebook to keep the lesson sheets, assignments, and notes.
- Answer sheets for both the Worksheets and the Tests have been placed in the Instructor's Manual for your use.
- Corrections for the Worksheets will be attached or listed in the Instructor's Manual. Please call attention to errors in printing when you make the assignment.
- THE FOUR-STEP OUTLINE

Each lesson plan is outlined into the "four-step" method of instruction and should assist you in presenting the lessons. In group instruction, it is recommended that the class period include the following:

- STEP I - INTRODUCING THE LESSON:
Call attention to interesting facts concerning the subject.
- STEP II - PRESENTING THE LESSON:
Demonstrate the use of necessary tools, materials, problems, and experiments. A well-presented lesson will require the student to do a minimum of reading in the assigned texts. Note: When adequate equipment is provided, each student can perform the experiments individually. Show films or slides related to the subject. Discuss problems encountered on the job.
- STEP III - APPLICATION:
Make use of the Assignment Sheets prepared for each lesson. The assignments serve not only as a valuable aid to the learner, but also indicate to the instructor how well the lesson was taught.
- STEP IV - CHECKING AND FOLLOW-UP:
Check the worksheets with the aid of answer sheets. This can be done quickly by the instructor or by exchange of papers in class. Return the papers to the students to correct mistakes and give individual help to those who need it. Call attention to common errors and discuss the problems or questions which were incorrect.

NOTE: Make assignments for the next week.

TESTING PROCEDURES:

1. Short tests can be given each week on the lesson or the previous assignment.
2. A thorough test should be given shortly after completing a unit or group of lessons. This test should cover six weeks work or less.
3. A good comprehensive test administered at the end of the course will act as a gauge of progress for the year. Some questions, with the use of charts, tables, and the National Electrical Code, can be of the "open book" type.
4. All tests should be checked in detail, reviewed in class, and returned to you. Tests should be retained by you and the committee as a part of the student's record.

- Please note that the assignment references for textbooks list the page numbers.

The National Electrical Code references are "Articles."

The American Electrician's Handbook lists the Division and Section; these are not the page numbers.

- TEXTBOOKS:

NOTE: Book stores at the institutions can order the textbooks and receive the school discount.

The National Electrical Code - latest edition.

American Electrician's Handbook by Croft, Carr, and Watt; 9th edition, 1970.

Basic Electricity by Van Valkenburgh, Nooger, and Neville; 1st edition, 1954, Volumes 1-5.

Basic Mathematics for Electricity and Electronics by Singer. 3rd edition, 1972.

AC Motor Control Fundamentals by McIntyre, 2nd edition. (Used for 3rd and 4th year assignments only.)*

- INSTRUCTIONAL MATERIALS:

The necessary materials should be ordered from the Department of Community Colleges, Program Development, Raleigh, N.C. 27602

1. Instructor's Manual - Third Year, Series C
2. Student Information Sheets and Worksheets-Third Year, Series C
3. Mathematics Pretest
4. Basic Mathematics Review
5. MAT 1111 - Slide Rule
6. Supplementary Materials List for Electrical Apprentice Technical Training
7. Tests (Series C) Copy of tests without answers is included in Instructor's Manual; please have your own student tests printed.

* 3rd Edition, 1972, is available.

ALTERNATING CURRENT

DESIRED RESULTS:

1. To acquaint the apprentice with the importance of alternating current.
2. To know the basic fundamentals of alternating current.
3. To study the terminology used in working with alternating current circuits.

EQUIPMENT AND MATERIALS:

- | | |
|-----------------|-----------------------|
| 1. Oscilloscope | 4. Relay |
| 2. Lamps | 5. Transformer (Bell) |
| 3. Motor | 6. Capacitor |

INTRODUCTION:

Alternating currents have been referred to briefly in other lessons. As you know, most all of the electric power generated and transmitted in the United States is alternating current.

Five reasons are listed for using electrical energy as alternating current rather than direct current:

1. The A. C. generators have no commutators. Therefore, units having larger power ratings and resultant heavier current ratings can be used without the problem of brush arcing and heating.
2. Because alternators or A. C. generators have no commutators, they can generate at comparatively high voltages such as 11,000 to 13,000 volts.
3. Because alternating current can be transmitted economically over great distances, it is possible to generate electrical energy in large quantities in a single station and distribute it over a comparatively large territory.
4. By the use of the transformer, alternating current can be increased or decreased easily without much power loss.
5. For constant speed work, the A. C. squirrel-cage induction motor is less expensive than the direct current motor, both in cost and in maintenance.
6. The term "cycle" has been changed to "hertz" to honor the founder of positive and negative alternations. We have retained the term cycle for its simplicity and descriptive value.

PRESENTING THE LESSON:

- A. The Cycle: Since we know that alternating current flows back and forth in a conductor at regular intervals, going first in one direction and then the other,
 - 1. Develop the concept of the cycle using the four positions of a loop in an elementary generator.
 - 2. Define cycle--Draw a waveform or sine wave and mark the points of maximum average, and effective values. Have the students give definitions of cycle.
- B. Discuss and define mechanical and electrical degrees
 - 1. Compare two and four pole A.C. generators--Calculate the mechanical and electrical degrees in each generator per turn of rotor coil.
 - 2. Arrive at the definitions.
- C. Frequency
 - 1. Compare the number of cycles generated per turn of rotor in two and four pole A.C. generators--Calculate the number of cycles generated per second in each generator at a given speed.
 - 2. Arrive at a definition of frequency.
- D. Phase
 - 1. Definition of single-phase.
 - 2. In-phase.
 - a. Give definition.
 - b. Illustrate VOLTAGE and CURRENT relationship using SINE WAVES.
 - (1) Draw waveform or SINE WAVE.
 - (2) Illustrate with OSCILLOGRAPH if available.
 - 3. OUT OF PHASE - LAG
 - a. Definition.
 - b. Illustration of SINE WAVES showing current lagging the voltage.
 - 4. OUT OF PHASE - LEAD
 - a. Definition.
 - b. Illustration of SINE WAVES showing current leading the voltage.
- E. Demonstrations with cathode ray oscillograph
 - 1. Cycle of line voltage sine waves.
 - 2. Waves of at least two different frequencies.
 - 3. Current and voltage--Connect a lamp to the line.
 - 4. Current lagging voltage--Connect a relay, a transformer, or a motor to the line.
 - 5. Current leading the voltage--Connect a capacitor to the line.

6. Visual Aids

Show "Alternating Currents"
35 MM Slide Film
Jim Handy Organization

(OR) Any other film on
Alternating Current

APPLICATION:

The students should complete the assignment sheet for this lesson.

CHECKING AND FOLLOW-UP:

Check the answers and return the sheets to the students for placing
in notebooks.

NAME _____

LESSON C-1

DATE _____

WORKSHEET

ALTERNATING CURRENT

1. Alternating current or voltage is one which is reversed at REGULAR intervals.
2. A cycle or "hertz" is a complete set of VALUES through which an alternating current passes.
3. One cycle or "hertz" is equal to 360° electrical degrees. (0°, 90°, 180°, 270°, 360°)
4. The expression "60 cycles or hertz per second" means that the current referred to makes 60 complete cycles in a second. (60, 120, or 30)
5. Most electric power companies generate, transmit, and distribute their power at 60 cycle frequency.
6. If 25 cycles are used for lighting, there will be FLICKERING of the lamps.
7. "Phase" is a term used to express time. True/False TRUE
8. Three-phase current is three different alternating currents 120° out of phase. True/False TRUE
9. Name three circuit characteristics that may affect the value of the current in an A.C. circuit. RESISTANCE, INDUCTANCE, and CAPACITANCE.
10. Effective values of ALTERNATING CURRENT and voltage are the ones ordinarily referred to when speaking of alternating quantities.
11. The maximum value of alternating current or voltage is THE GREATEST VALUE THAT IT ATTAINS.
12. The average value of alternating current or voltage is AVERAGE OF THE INSTANTANEOUS VALUES FOR 1/2 CYCLE and .636 times MAXIMUM VALUE.
13. The EFFECTIVE value of alternating current or voltage is 0.707 times MAXIMUM VALUE.
14. Effective average power is equal to product of EFFECTIVE voltage and EFFECTIVE current.

15. Magnetic field expanding and contracting with a VARYING
CURRENT produces inductance.
16. Inductance produces OPPOSITION to flow of current and makes
the current LAG the VOLTAGE.

RESISTANCE IN A. C. CIRCUITS

DESIRED RESULTS:

1. To acquaint the student with the effect of resistance only in A. C. circuits.
2. To understand the meaning of the term "power factor."

EQUIPMENT AND MATERIALS:

- | | |
|-----------------|---------------------|
| 1. Oscilloscope | 4. Meters |
| 2. Lamp bank | 5. A. C. Generators |
| 3. Switches | 6. Capacitor |

INTRODUCTION:

The effect of resistance in alternating current circuits which contains resistance only is the same as its effect in direct-current circuits. It causes a loss or drop in voltage, with a specified voltage, the greater the resistance, the smaller the current and vice versa. Remember that some materials have much less resistance than others. Pure resistance circuits are made up of electrical devices such as resistors, lamps, and heating elements which have negligible inductance or capacitance. When only such devices are used in an A. C. circuit, Ohm's Law, and the circuit rules for voltage, current, and power can be used in D. C. circuits.

Power in the A. C. circuit is determined in a similar manner as in a D. C. circuit by multiplying volts and amperes. When the power factor is other than unity, all A. C. voltage and current are given in effective values. Effective values are determined by considering the angle of lag or lead between voltage and current.

The power represented by the product of volts, amperes, and cosine is registered on a wattmeter or a watt-hour meter. It represents the power you pay for when furnished by the electric company.

PRESENTING THE LESSON:

1. Review the fundamental concepts of power
 - a. A. C. resistance circuits
 - b. Draw voltage and current wave

- (1) Sine waves of voltage and currents are "in phase" whenever they are the same frequency and pass through zero simultaneously, both going in the same direction.
 - (2) Demonstrate on the oscilloscope.
 - (3) Set up a circuit of incandescent lamps to A.C. power supply. Measure the volts, amps, and watts. Show that volts x amps equals watts.
2. Determination of power
- a. Circuit having resistance only--Measure the volt-amps and power supplied to:
 - (1) A reactor of negligible resistance.
 - (2) A capacitor.
 - b. Circuit having inductive or capacitive reactance--Measure the power supplied to a single-phase induction motor.
3. Present the general formula for single phase or A.C. power factor.

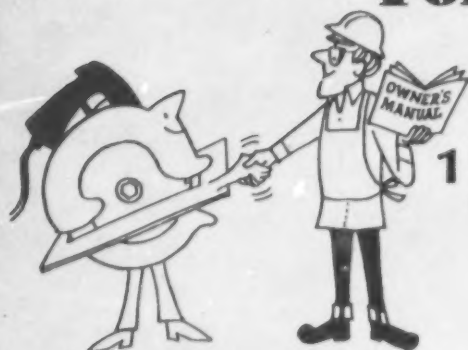
APPLICATION:

Have the students answer all questions; show all formulas used on the assignment sheet.

CHECKING AND FOLLOW-UP:

After checking the papers, return the sheets to the students for correction and placing in their notebooks.

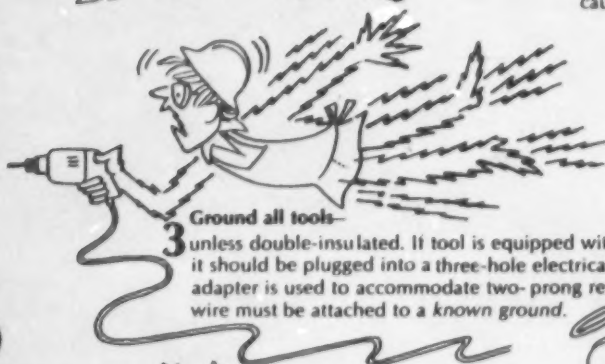
On-the-job SAFETY RULES For Power Tool Operation



1 Know the tool you are using—its application, limitations and potential hazards.



2 Select proper tool for the job. Don't try to tackle a big job with an undersized tool—makeshift tools can cause accidents.



3 Ground all tools—unless double-insulated. If tool is equipped with three-prong plug, it should be plugged into a three-hole electrical receptacle. If adapter is used to accommodate two-prong receptacle, the adapter wire must be attached to a known ground.



6 Keep guards in place and in working order. Do not remove or wedge out of the way.



4 Remove adjusting keys and wrenches before turning on tool.



7 Always be alert to potential hazards in your working environment such as damp locations or the presence of highly combustible materials—gasoline, naptha, etc.



5 Keep work area free of clutter—boards, boxes, debris, tools, etc.—that can be tripping hazards.



8 Avoid accidental startup. Make sure switch is off before plugging in cord—or when power is interrupted. Don't carry plugged in tool with finger on switch.

9 Make sure saw blades, drill bits, router cutters, etc. are sharp, clean and regularly maintained.

10 Use only recommended accessories. Follow manufacturer's instructions.

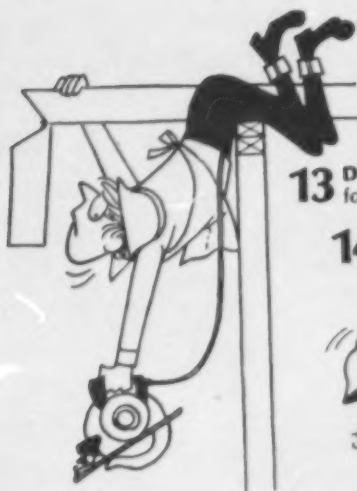


12 Use safety glasses. Also face or dust mask if operation requires it.

11 Do not force tool. It will do a better and safer job at its designed speed.



17 Dress properly. Avoid loose clothing that could catch in moving parts. Wear rubber boots in damp locations.



13 Do not overreach. Keep proper footing and balance at all times.

14 Never leave tool running unattended. Don't leave until it comes to a complete stop and is disconnected from power source.



19 Do not use tool with frayed cord. Return it for servicing. Use only heavy duty U.L. listed extension cords of proper wire size and length.

18 Secure work. Use clamps or vise to hold work when practical. It frees both hands to operate tool.



15 Don't surprise or touch anyone operating a power tool. The distraction could cause a serious accident.

20 Never brush away chips or sawdust while tool is operating.



16 Never adjust, change bits, blades or cutters with tool connected.



21 Do not attempt field repairs. Return for servicing any tool that shows slightest defect or is not operating properly.



22 Store tools in dry, secure location where they won't be tampered with.

28

DOTY

NAME _____

LESSON C-2

DATE _____

WORKSHEET

RESISTANCE IN A. C. CIRCUITS

1. List two factors which may cause an increase in resistance in A. C. circuits:
(a) INDUCTANCE (b) CAPACITANCE
2. Pure resistance circuits consist of electrical devices containing no INDUCTANCE or CAPACITANCE.
3. EFFECTIVE values of A. C. voltage and current must be used in circuit laws and rules.
4. For practical use, all A. C. voltage and current values are given as EFFECTIVE values.
5. In a resistive circuit, Ohm's Law and Kirchhoff's Laws can be used as is in a AC DC circuit.
6. VOLTAGE and CURRENT are in phase in resistive circuits.
7. What is meant by the term "in phase"? CORRESPONDING VALUES FOR CURRENT AND VOLTAGE ARE THE SAME AT ANY GIVEN TIME.
8. The value of voltage in A. C. circuits at 0°, 180°, and 360° is 0.
9. AVERAGE power is the actual power used in an A. C. circuit.
10. Average power is exactly one-half of MAXIMUM instantaneous VALUE.
11. Power is equal to the product of VOLTS and AMPERES.
12. Power is expressed in terms of WATTS or VOLT AMPERES.
13. Resistance is expressed in terms of OHMS.
14. Power factor is expressed in PERCENT or DECIMALS.
15. Power factor in a resistive circuit has a value of 1 (ONE).

16. Power factor is the ratios of WATTS of the circuit and VOLT
AMPERES of the circuit.

17. Find the power and the power factor of a resistive circuit with impressed voltage of 220 volts and current of 10 amperes.

$$PF = 1 \text{ (IN A RESISTIVE CIRCUIT)}$$

$$PF = 220 \times 10 \times 1 = 2200 \text{ WATTS}$$

$$P = R \times E$$

$$P = 220 \times 10 \times 1 = 2200 \text{ WATTS}$$

18. A water heater rated 5000 watts is connected on a 220 volt system. Find the current in the A. C. circuit.

$$I = \frac{5000}{220} \left(\frac{R}{E} \right)$$

$$I = 22.75 \text{ AMPERES}$$

INDUCTANCE AND INDUCTIVE REACTANCE

DESIRED RESULTS:

1. To acquaint the apprentice with the effects of inductance in an alternating current circuit.
2. To show the effects of inductive reactance in an A. C. circuit.

EQUIPMENT AND SUPPLIES:

- | | |
|--|---------------------|
| 1. Resistors, coils, capacitors, lamps | 6. Core Materials |
| 2. Oscilloscope | 7. Bell Transformer |
| 3. Connecting wire | 8. Light bulbs |
| 4. 16 MM Projector and film | 9. Coils |
| 5. Resistors | 10. Meters |

INTRODUCTION:

INDUCTANCE, which is treated in this assignment, is the electrical property that in an A. C. circuit imposes a counter or back voltage. When the current increases, inductance tries to hold it down and when the current decreases, inductance tries to hold it up. While you cannot see inductance, it is present in every electrical circuit and has the above effects on the circuit whenever the circuit current changes.

Inductance of a circuit is measured in a unit called "henrys." It is expressed by the symbol L. A circuit has an inductance of 1 henry when, if the current is changed at the rate of 1 ampere per second, 1 volt is induced into the circuit. You must understand inductance and inductive reactance in order to learn the basics of alternating current.

Inductive reactance is the opposition to current flow offered by the inductance of a current. As you know, inductance only affects current flow while the current is changing, since the current change generates an induced EMF. Reactance is expressed in Ohms as in resistance. In the formula inductive reactance is represented by the letters X_L .

Because an understanding of inductance and inductive reactance is fundamental to an understanding of alternating current, be sure that the students master this material including the use of formulas.

PRESENTING THE LESSON:

Remember that an alternating current is continuously changing so that the circuit inductance affects A. C. current flow at all times.

Because a coil of wire has more inductance than a straight length of the same wire, the coil is called an "inductor."

Resistors, coils, and capacitors may be connected in series in several combinations. A circuit which contains a resistor connected in series with a coil will be considered.

Resistors and coils offer opposition to alternating current. The voltage and current relationship in a resistor will be in phase while in a coil; the current lags the voltage drop across the coil by 90 degrees. The combined opposition is called impedance and is measured in ohms.

Show the following waveforms on the chalkboard:

1. A.C. voltage and current waveforms in an inductive circuit.
2. How frequency affects current.
3. Voltage and currents are in phase in a circuit of pure resistance.
4. Voltage and currents are 90° out of phase in a circuit of pure inductance.

DEMONSTRATIONS:

1. Analyze a series circuit containing two resistors or lamps.
2. Analyze a series circuit containing a resistor in series with a coil.
3. Set up a series circuit consisting of a resistor and a coil, each having corresponding resistance and reactance of about the same value.
4. Show the actual relationship of voltage and current in each part of the circuit by using an oscilloscope.
5. Show how inductance varies with core material.
6. Determine the starting voltage of a neon lamp.
7. Observe A.C. and D.C. current flow in a resistive circuit.
8. Show how inductive reactance affects the total circuit current.

NOTE: Show film "Inductance in A.C. Circuits," if available.

APPLICATION:

Have the students answer the questions and work the problems on the Assignment Sheet.

CHECKING AND FOLLOW-UP:

Check the answers and help any of the students who had trouble with the questions or problems.

NAME _____

LESSON C-3

DATE _____

WORKSHEET

INDUCTANCE AND INDUCTIVE REACTANCE

1. Inductance exists because an electric current produces a COUNTER EMF.
2. The strength of the MAGNETIC FIELD is dependent on the change of current.
3. Small current flow produces a SMALL magnetic field.
4. Large MAGNETIC FIELD is produced by a LARGE current flow.
5. Magnetic field expands and contracts with varying current causing an EMF of varying VOLTAGE and the effect known as CEMF.
6. No current flow produces no COUNTER EMF.
7. Inductance is produced only with a CHANGE IN CURRENT.
8. In a D. C. circuit, a constant current produces NO inductance.
9. In a D. C. circuit, inductance is produced only when the power is TURNED ON or TURNED OFF.
10. "L" is the letter symbol for INDUCTANCE.
11. When the current increases, INDUCTANCE attempts to hold it down.
12. "Henry" is the unit of measure of INDUCTANCE.
13. Unit of inductive reactance is OHM.
14. Symbol of inductive reactance is X_L .
15. Inductive reactance is the opposition to the flow of changing current due to INDUCTANCE.
16. In D. C. circuits EFFECTIVE REACTANCE occurs only when current is turned on or off.
17. In 60 cycle A. C. circuits, inductive reactance occurs 120 times per second.
18. PHASE ANGLE is the amount in degrees by which the current lags the voltage.

19. The phase angle depends on INDUCTANCE and RESISTANCE.

20. Find the inductive reactance of a coil with an inductance of 15 henrys at 60 cycles.

$$(2 \pi FL) \quad 6.28 \times 60 \times 15 = 5,650 \text{ OHMS}$$

21. Find the inductive reactance of a 15-henry coil at 120 cycles.

$$(2 \pi FL) \quad 6.28 \times 120 \times 15 = 11,295 \text{ OHMS}$$

22. Find the voltage drop across a coil having an inductive reactance of 942 ohms and a 2-ampere current flow.

$$E_L = I_L \times X_L$$

$$E_L = 2 \times 942 = 1884 \text{ OHMS}$$

CAPACITANCE AND CAPACITIVE REACTANCE

DESIRED RESULTS:

1. To help clarify the concept of capacitance by showing that when the voltage across an electric circuit changes, the circuit opposes this change.
2. To acquaint the student with the effects of capacitance reactance in an alternating current circuit.

EQUIPMENT AND SUPPLIES:

- | | |
|------------------------|---|
| 1. Two-plate capacitor | 7. Power supply transformer |
| 2. Knife switch | 8. Resistors |
| 3. Dry cell | 9. Various types of capacitors |
| 4. Ammeter | 10. Wire connections |
| 5. Voltmeter | 11. 16 MM projector |
| 6. Lamps | 12. 16 MM Film--"Capacitance in A. C. Circuits" |

INTRODUCTION:

- A. Capacitance exists in an electric circuit because certain parts of the circuit are able to store electric charges. Capacitance is dependent on the area of the metal plates, the characteristics of the dielectric, and the distance between the plates. The effectiveness of a dielectric for use in a capacitor is described by a number called the "dielectric" constant. The number is based on the assumption that air has a dielectric of 1. Bakelite varies from 4.0 to 10.0, rubber compounds from 3.0 to 7.0, and paper from 2.0 to 2.6.
- B. Capacitive Reactance is the opposition to current flow offered by the capacitance of a circuit. It is measured in ohms, the same as resistance and inductive reactance. Capacitive reactance is designated by the symbol X_C . Alternating current continuously varies in value and polarity; therefore, the capacitor is continuously charging and discharging, resulting in a continuous circuit current flow and a finite value of capacitive reactance.

Inductive reactance and capacitive reactance have exactly opposite effects in a circuit. Inductive reactance opposes change of current in a circuit; capacitive reactance opposes change in voltage. In a series circuit the inductive reactance tends to neutralize the capacitive reactance.

PRESENTING THE LESSON:

A. What factors determine the reactance?

1. The size of the capacitor is one factor. The larger the capacitor, the greater the number of electrons that may be accumulated on its plates.
2. Increasing the distance between the plates decreases capacitance.
3. Changing the dielectric material changes the capacitance. Example, using mica as a dielectric increases the capacitance.

B. What is working voltage?

The working voltage is the largest voltage that may be placed across a capacitor before it breaks down. The working voltage in a parallel circuit is the working voltage of the weakest capacitor. The working voltage in series circuit is the sum of the working voltages of the series capacitor. See formulas--Basic Mathematics.

C. Show by drawing on the chalkboard and using the text Basic Electricity:

1. Charging and discharging currents of a capacitor.
2. How frequency affects the flow of A.C. current through a capacitor.
3. How capacitance values affect capacitive resistance.
4. In a pure capacitive circuit, how the current leads the voltage.
5. The power wave of a circuit containing only capacitance.

DEMONSTRATIONS:

A. Use Basic Electricity

1. Charging a plate NEGATIVELY and POSITIVELY.
2. D.C. current flow stops when the capacitor becomes charged. Switch closed--capacitor charges. Switch open--capacitor remains charged. Switch reversed--capacitor discharges and then charges with reversed polarity.
3. A.C. current in a capacitive circuit--charge and discharge currents cause a deflection on the A.C. ammeter.
4. To prove that capacitors appear to block D.C. but permit A.C. to pass.

B. Demonstrate Basic Electricity, Volume 3

1. A voltmeter connected across a capacitor acts as a RESISTOR.
2. A neon lamp is an open circuit until its starting voltage is reached.
3. Observe the time delay of an R. C. time constant.
4. Show that a change in resistance changes the R. C. time constant.
5. Show that a change in capacitance changes the R. C. time constant.
6. Observe the charging current of a capacitor.
7. Observe the capacitance reactance as the capacitance changes.

C. Show the film--"Capacitance in A. C. Circuits," if available.

REVIEW of Capacitance in A.C. circuits by having the students explain the terms and items brought out in the film:

1. Capacitance
2. Capacitor
3. Capacitor charge
4. Capacitor discharge
5. Farad
6. Microfarad
7. Micromicrofarad
8. Dielectric

APPLICATION:

Have the students complete the questions on the assignment sheet for this lesson.

CHECKING AND FOLLOW-UP:

After checking the papers, return them to the students for correction and placing in their notebooks.

NAME _____

LESSON C-4

DATE _____

WORKSHEET

CAPACITANCE AND CAPACITIVE REACTANCE

1. The letter symbol for capacitance is C.
2. The unit of capacitance is OHM.
3. Capacitance is the ABILITY of a circuit to store electrical energy.
4. Two conducting materials separated by an insulating material are called CAPACITOR or CONDENSER.
5. In an A. C. circuit, a capacitor is constantly CHARGING and DISCHARGING.
6. The effect of capacitance in an A. C. circuit is that it produces OPPOSITION to the flow of CURRENT.
7. In a pure capacitive circuit, the current will lead the voltage by 90°.
8. One microfarad is $\frac{1}{1,000,000}$ farad.
9. The total value of capacitors connected in parallel is the SUM of the capacities of the individual capacitors.
10. Find the total capacity in parallel of 15-uf, 45-uf, and 10-uf capacitors. $C_T = 15 + 45 + 10 = 70$
11. The symbol for capacitive reactance is X_C .
12. The unit of capacitive reactance is OHM.
13. The opposition to alternating current produced by capacitance is CAPACITIVE REACTANCE.
14. Capacitive reactance is inversely proportioned to the product of the FREQUENCY and capacitance.
15. Phase angle is the amount in degrees by which the current LEADS the voltage.

16. Small capacitor has a LARGE reactance.
17. Large capacitor has a SMALL reactance.
18. Find the capacitive reactance of a 10-uf capacitor at 60 cycles.

$$X_C = \frac{1}{2 \pi FC}$$

$$X_C = 265 \text{ OHMS}$$

POWER FACTOR CORRECTION

DESIRED RESULTS:

To acquaint the student with the method and importance of power factor correction.

EQUIPMENT AND MATERIALS:

1. Chalkboard
2. A capacitor (large kva) for demonstration

INTRODUCTION:

Power is the rate of doing work. A watt is the unit of power or equal to the work done by the current of one ampere under the pressure of one volt. A wattmeter is not constructed with the basic meter movement. It used field coils with no permanent magnet to furnish the magnetic field. Since wattmeters work differently than other meters and are easily damaged if connected incorrectly, they must be operated properly.

Measurement of Power Factor can be done by using a power factor meter. The exterior of the single-phase power factor meter is identical to the wattmeter. While a source may produce volts and amperes, the power in watts may be small or zero. The ratio between the power in watts of a circuit and the volt-amperes of a circuit is called "power factor." In a pure resistive circuit the "power factor" is equal to power in watts divided by volt-amperes which equals one (1).

PRESENTING THE LESSON:

The ideal power transmission occurs when the current is in phase with the voltage or when the "power factor" is one (1). This can be accomplished by connecting a capacitor or a bank of capacitors across the line or in parallel with the inductive equipment. Show the students a capacitor.

The size of the capacitor is determined from tables showing the relationship between "power-factor," load kva and kva capacitors needed for any desired new power-factor. The size of capacitor necessary to raise the power factor of a given load to a higher value can be found as follows:

Assume a 500 kva load at 60 percent power factor; $500 \text{ kva} \times 0.60 = 300 \text{ kw}$. It is desired to raise the power factor to 90 percent. The

capacitor kva necessary is found by multiplying 300 kw by the factor taken from the power factor correction table, which is 0.85. The capacitor needed would be 255 kva.

The power-factor correction theory is not in the realm of apprentice work or the electrical maintenance department. It is an engineering problem and engineers should calculate the problems with the actual correction being made with capacitors or synchronous motors. The maintenance electrician should be familiar with the dangers in working with capacitors. A capacitor can maintain a charge sufficient to produce a fatal shock for a long time after it is disconnected from a charged line. A capacitor should be fully discharged before any maintenance work is done to it or around it.

APPLICATION:

The students will complete the questions and solve the problem on the assignment sheet.

CHECKING AND FOLLOW-UP:

The answers should be checked and the papers returned to the students for correction and filing in their workbooks.

NAME _____

LESSON C-5

DATE _____

WORKSHEET

POWER FACTOR CORRECTION

1. A synchronous CONDENSER is a synchronous motor used to correct power factor only and does not pull any MECHANICAL load.
2. Synchronous motors may be used to CORRECT low power factor of a system.
3. Lower power factors INCREASE the total current of a circuit.
4. Low power factor may be due to large power consumption by under-loaded INDUCTION motors.
5. The true POWER is the actual power which may be measured by a watt meter.
6. Power factor is the ratio of power in watts to power in volt amperes
True/False TRUE - APPARENT
7. Find the capacitor rating necessary to raise the power factor to unity of an induction motor rated 7 1/2 HP at 440 volts. Draw vector diagram.

$$VARP = VA \times \text{SIND}$$

$$\text{COSO} = \frac{W}{VA}$$

$$W = 746 \times 7.5$$

$$VARP = 5595 \times 1$$

$$\text{COSO} = \frac{5595}{5595}$$

$$W = 5595 \text{ WATTS}$$

$$VARP = 5595$$

$$\text{COSO} = 1$$

$$1 = \frac{P}{E}$$

$$\text{SIND} = V$$

$$\text{COSO} = 0^\circ$$

$$1 = 12.7$$

CAPACITORS

DESIRED RESULTS:

To acquaint the apprentice with construction, installation, use, markings, and protection of capacitors needed for industrial use.

MATERIALS:

1. A. C. supply, meters, and oscilloscope
2. 100 W. lamp, 10 and 5 mfd capacitors, switches
3. a. 16mm. sound film - Capacitance - U. S. Navy - Castle No. 15402
b. 35mm. - Filmstrip - Capacitive Reactance - U. S. Navy Castle No. SN648
4. Samples: Industrial Capacitor and Motor Capacitor

INTRODUCTION:

Practically all electrical apparatus is composed of a combination of resistors or coils. Some industrial equipment such as capacitor motors, capacitor banks, and automatic switchgear use capacitors. Many kinds of capacitors are used in electricity and electronics. In order to choose the best type for a particular job, you should know how they are made and operate. You should be familiar with the symbols used to indicate certain special types of capacitors. Capacitors consist of two plates of electrical conducting material such as aluminum or tin, separated by an insulating material called the "dielectric," such as air, waxed paper, mica, glass, etc.

PRESENTING THE LESSON:

- I. The meaning of capacitance
 - A. Physical construction of a capacitor--Two conductors with insulation between them
 - B. Characteristics of a capacitor
 1. Will not pass current
 2. Will hold a current
 - C. Demonstration of the action of a capacitor--Show diagram and set up circuit.

Test 1 - Close the switch and note the ammeter reading. Instantaneous current indication is followed by zero reading.

Test 2 - Open the switch and connect a suitable scale voltmeter to the terminals of the capacitor about one minute after the switch is opened. The voltmeter will read instantaneously and fall to zero as the charge is absorbed by the meter.

II. Measurement of capacitive reactance effect

- A. Demonstrate the effects of capacitive reactance in a lighting current.

Test 1 - Insert a capacitor of about 10 mfd capacity in the circuit. Note the brilliancy of the lamp.

Test 2 - Replace the 10 mfd capacitor with 5 mfd capacitor. Note the brilliancy of the lamp. Current decreases with a decrease of capacitor. Reactance effect increases with decrease of capacitor.

- B. Review the characteristics of capacitive reactance.

1. Review the formula for capacitive reactance.
2. Calculate the reactance of each capacitor used in the demonstration.
3. Calculate the current for each demonstration.

III. Effect of the capacitor on voltage - current relationship
Connect a cathode ray oscilloscope in the circuit of a capacitor which is across an A. C. line.

IV. Visual aids

- A. Show samples of models of an industrial capacitor and a motor capacitor.
B. Show the films. Discussion of the films.

APPLICATION:

Have the students complete the assignment questions.

CHECKING AND FOLLOW-UP:

After checking the answers, return the papers to the students for corrections and filing in their notebooks.

NAME _____

LESSON C-6

DATE _____

WORKSHEET

CAPACITORS

1. An installation of capacitors in which any single unit contains more than (A) 3 gallons of combustible liquid shall be in a vault.
(a) 3 (b) 4 (c) 5
2. Capacitor shall be provided with NON - COMBUSTIBLE cases and supports.
3. Capacitor cases shall be grounded in accordance with Article (A) 250.
(a) 250 (b) 460 (c) 680
4. The ampacity of capacitor circuit conductors shall be not less than (A) 135 percent of the rated current of the capacitor.
(a) 135 (b) 125 (c) 100
5. The continuous ampacity of the disconnecting device shall be not less than (C) 135 percent of the rated current of the capacitor.
(a) 100 (b) 125 (c) 135
6. List two means of capacitor discharge: (a) PERMANENTLY
(b) AUTOMATIC
7. For greater power factor correction effect, the capacitor should be located at the LOAD.
8. An installation of capacitors for power factor correction will provide a reduction in power costs. True/False TRUE
9. Capacitors in hazardous locations shall comply with additional requirements in Articles 500 through 517.
10. When can the disconnecting means be omitted at the capacitor? WHEN
CONNECTED TO LOAD SIDE OF A MOTOR OVERCURRENT DEVICE.
11. The current carrying capacity of a disconnecting device shall be a minimum of 135 percent of the rated current of the capacitor.
12. An overcurrent device shall be installed in each UNGROUNDED conductor.

WORKSHEET

LESSON C-6

13. Is it necessary for the disconnecting means to open all ungrounded conductors simultaneously? NO
14. Are capacitor cases required to be grounded? YES

Join the WAR ON WASTE



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POWER IN AC CIRCUITS

DESIRED RESULTS:

1. To understand the meaning of the term "Power Factor."
2. To show the apprentice how power in an AC circuit is determined.

EQUIPMENT AND MATERIALS:

- | | |
|--------------------|-----------------------------------|
| 1. Voltmeter | 5. Motor or industrial power load |
| 2. Ammeter | 6. Lamp banks |
| 3. Wattmeter | 7. Capacitors |
| 4. AC power supply | 8. Resistors |

INTRODUCTION:

The power in a DC circuit is the product of volts and amperes. In an AC circuit, the voltage and current are seldom in phase. Incandescent lighting and heating are the exceptions. The apparent power or product of volts and amperes must be multiplied by a "power factor" to determine the true or real power.

Refer to AC Power Waveform, Basic Electricity.

For "in phase" voltage and current waves, all of the instantaneous powers are above the zero axis and the entire curve is above the zero axis. This is determined when two positive values are multiplied together, the result is positive, and whenever two negative values are multiplied together, the result is also positive.

PRESENTING THE LESSON:

- I. Fundamental concepts of power
 - A. AC resistance circuits
 - B. AC inductive circuits
 - C. AC capacitive circuits
- II. Determination of power
 - A. Circuit having resistance only
 - B. Circuit having inductive reactance or capacitive reactance
 - C. Circuit having a reactive load (capacitive or inductive)
 - D. General formula for "single phase" or AC power
 - E. Measurement of AC power
- III. Power factor--Concept, definition and determination of power factor

IV. Demonstrations

- A. Set up circuits of incandescent lamps connected to an AC supply. Measure the volts, amperes, and watts. Show that volts x amperes equals watts.
- B. Measure the volt ampere and power supplied to:
 - 1. A reactor of small resistance
 - 2. A capacitor
- C. Measure the volts, amperes, watts, or the power supplied to a single phase induction motor

APPLICATION:

The students will answer the questions and solve the problems on the Assignment Sheet. Give assistance with the problems where needed.

CHECKING AND FOLLOW-UP:

After checking the answers, return the sheets to the students for corrections and placing in their workbooks.

NAME _____

LESSON C-7

DATE _____

WORKSHEET

POWER IN AC CIRCUITS

1. The power in any electrical circuit is the product of VOLTAGE and CURRENT flowing at that time.
2. In a resistive circuit, power is found by multiplying the effective VOLTAGE by effective CURRENT.
3. Apparent POWER is the product of the voltage and current.
4. Apparent power units are in VOLT AMPERES.
5. True power units are measured in WATTS.
6. Write the formula for finding true power in watts.

$$I^2 R = \text{TRUE POWER IN WATTS OR } E^2 / R = \text{TRUE POWER IN WATTS}$$
7. The ratio of true power to apparent power is called POWER FACTOR.
8. Find the power factor of a motor drawing 500 watts and 5 amps from a 120-volt 60-cycle line.

$$PF = \frac{W}{VA} = \frac{500}{120 \times 5} = \frac{500}{600} = .83 \text{ OR } 83\%$$
9. Lights and motor loads of a store draw 32 kw. The power factor of this load is 75 percent. Find the apparent power delivered to the store.

$$VA = \frac{W}{PF} = \frac{32000}{.75} = 42666 \text{ V.A OR } 42.6 \text{ KVA}$$
10. In an inductive circuit, the reactive power LAGS the true power.
11. In a capacitive circuit, the reactive power LEADS the true power.
12. A three phase current consists of THREE alternating currents that DIFFER in phase by 120 degrees.
13. The currents in a three phase circuit will be 120 degrees out of phase with each other.

HAZARDOUS LOCATIONS

DESIRED RESULTS:

1. To acquaint the student with the three classes of hazardous locations and the general type of wiring permitted in each place.
2. To be able to recognize a hazard and develop the ability to classify the hazard involved.

INTRODUCTION:

The assigned material for the next lessons deals with wiring in areas where there is danger of explosion or fire resulting from operation of the electrical installation. The CODE breaks down the various types of hazardous locations into three classes. Various types of wiring and equipment have been specified for the different kinds of hazards. Class I deals with activities in which fire or explosion may result from gases or vapors. Class II deals with dusts and Class III is reserved for combustible fibers. There are two small divisions under each class. In the first section, the particular danger is imminent at any or all times during the normal course of operation. In the second section, the danger is not believed present under ideal conditions. It is likely to arise from a reasonably foreseeable accident.

PRESENTING THE LESSON:

First, the students should review the particular kinds of hazards covered by the three main classes and the general type of wiring permitted in each location.

Second, the detailed requirements for each subclass should be carefully read.

The main benefits to be derived from this study are the ability to recognize a hazard and the ability to decide upon a rough classification of the hazard involved. After the wireman has accomplished this much, he should then study the more detailed rules concerning installation.

SUGGESTED DISCUSSION ITEMS:

1. What is the principle of operation of a dielectric paint spray unit?
What precautions would you suggest for preventing spark-over?

2. In a booth where lacquers are sprayed on small machine parts, which is the greater hazard, explosion or fire?
3. A motor is installed in the basement of a three-story garage building. This motor drives a blower which draws gasoline fumes out of the garage through a sheet-metal duct system to the outside of the building.
 - a. What type of induction motor is required for the operation?
 - b. Suppose the blower was installed on the roof instead of in the basement. Would this change in location affect your reply?
4. Gasoline in closed containers is stored in a large room. Through the upper part of the room, a 2-inch pipe carries high test gasoline from a pump located outside the room to a tank located on the other side of the room.

What type of hazard exists in the room?
5. A certain industrial building has quantities of dry dust suspended in the air.
 - a. What class of hazard does this constitute?
 - b. Can you suggest a simple expedient for reducing the hazard inside the building?

VISUAL AIDS:

Show 16 mm Film--"Preventing Fires Through Electrical Safety"
Employers Mutual Liability Insurance Co. of Wisconsin, Wausan,
Wisconsin, or other suitable film.

APPLICATION:

Have the students answer questions on the Assignment Sheet.

CHECKING AND FOLLOW-UP:

Check the answers and return the sheet to the students to be placed in their workbooks.

NOTE OF THANKS

This note will act as the acknowledgment for the reproduction of materials used as Information Sheets for "Hazardous Areas."

The revision committee wishes to thank the Crouse-Hinds Code Digest for the permission to use their series of "Hazardous Locations" information for instructional material in the Third Year Electrical Apprentice Technical Training.

The instructors and the students should profit by using this up-to-date information organized in such a compact and usable reference.

"Code excerpts reprinted with permission from the 1978 N.E. Code.

Howard E. Hedinger
Educational Consultant

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I. Classification of Hazardous Atmospheres

Crouse-Hinds Code Digest

A. Definitions.

The definitions below are extracted from the 1975 National Electrical Code. These definitions are included to define and clarify the meaning and intent of Crouse-Hinds when terms such as "Explosion-proof" and "Dust-ignition-proof" are used in this publication.

"Explosion-proof Apparatus": Apparatus enclosed in a case that is capable of withstanding an explosion of a specified gas or vapor which may occur within it and of preventing the ignition of a specified gas or vapor surrounding the enclosure by sparks, flashes, or explosion of the gas or vapor within, and which operates at such an external temperature that a surrounding flammable atmosphere will not be ignited thereby.

"Dust-ignition-proof," as used in this Article shall mean enclosed in a manner that will exclude ignitable amount of dusts or amounts that might affect performance or rating and that, where installed and protected in accordance with this Code, will not permit arcs, sparks, or heat otherwise generated or liberated inside of the enclosure to cause ignition of exterior accumulations or atmospheric suspensions of a specified dust on or in the vicinity of the enclosure.

The National Electrical Code, which is widely used for classification purposes, divides atmospheric explosion hazards into three broad classes; they are summarized in Table 1. However, it must be understood that considerable skill and judgment must be applied when deciding to what degree an area contains hazardous concentrations of vapors, combustible dusts or easily ignitable fibers and flyings. Many factors, such as temperature, barometric pressure, humidity, ventilation, distance from the vapor source, etc. must be considered. When information on all factors concerned

is properly evaluated, a consistent classification for the selection and location of electrical equipment can be developed. For further information on classification of areas see NFPA 70C.

The table shown in Appendix I lists many of the hazardous compounds used in business and industry, with their classification, flash points, ignition temperatures, explosive limits and vapor densities.

B. The National Electrical Code and Underwriters Laboratories.

The NEC is considered the definitive classification tool and contains explanatory data about ethyl ether (Class I, Group C) as used in hospital operating rooms, and for gasoline (Class I, Group D) as it may apply to storage areas, garages and gasoline stations. Specific installation practices have been set up for these heavier-than-air vapors. However, there is no such specific data for acetylene, whose vapor density is very near that of air. In the case of hydrogen used indoors, since its vapor density is so low, the most hazardous concentrations are likely to be in the upper portion of the room. A safe approach to electrical installations in Group A & B atmospheres is to install Class I equipment, or consult local inspectors for ruling on area classification.

Most states, municipalities and public service companies use the NEC as a guide for their inspectors.

Underwriters' Laboratories, Inc. (U/L) is a not for profit, independent organization testing for public safety. Its function is to determine whether or not devices and materials submitted to it are safe and can be used in the NEC category for which they were designed. To do this, it maintains extensive laboratory and testing facilities.

U/L's function does not include actual enforcement of the National Electrical Code. However, as previously indicated, inspection authorities use U/L's listing as criteria in carrying out their inspections of hazardous areas.

C. Class I Atmospheric Hazards.

Class I atmospheric hazards are divided not only into the four groups shown in the table, but also into two divisions.

Division 1 covers locations where flammable gases or vapors may exist under normal operating conditions, under frequent repair or maintenance operations, or where breakdown or faulty operation of process equipment might also cause simultaneous failure of electrical equipment.

Division 2 covers locations where flammable gases, vapors or volatile liquids are handled either in a closed system, or confined within suitable enclosures, or where hazardous concentrations are normally prevented by positive mechanical ventilation. Areas adjacent to Division 1 locations, into which gases might occasionally flow, would also belong in Division 2.

D. Class II Atmospheric Hazards.

Class II atmospheric hazards cover three groups of combustible dusts. Groups E and F are always Division 1. Group G may be either Division 1 or 2.

E. Class III Atmospheric Hazards.

Class III atmospheric hazards cover combustible fibers or flyings not likely to be in suspension in air in quantities sufficient to produce ignitable mixtures (Division 1.) and locations in which easily ignitable fibers are stored or handled (Division 2.).

The use of excerpts from Article 500 of the 1975 National Electrical Code, copyright National Fire Protection Association, Boston, MA, does not constitute or imply an endorsement by the NFPA of any of the Crouse-Hinds equipment listed in the Code Digest. NFPA does not endorse any product.

II. Prevention of External Ignition and Explosion

Crouse-Hinds Code Digest

A. Sources of Ignition.

A source of energy is all that is needed to touch off an explosion when flammable gases or combustible dusts are mixed in the proper proportion with air.

One prime source of energy is electricity. Equipment such as switches, circuit breakers, motor starters, push button stations, or plugs and receptacles, can produce arcs or sparks in normal operation when contacts are opened and closed. This could easily cause ignition.

Next in degree of hazard are devices that produce heat, such as lighting fixtures and motors. Here, surface temperatures may exceed the safe limits of many flammable atmospheres. A loose lamp in a fixture socket presents a double hazard, as it may combine arcing with production of heat.

Finally, many parts of the electrical system can become potential sources of ignition in the event of insulation failure. This group would include wiring (particularly splices in the wiring), transformers, impedance coils, solenoids, and other low-temperature devices without make-or-break contacts.

Non-electrical hazards such as sparking metal can also easily cause ignition. A hammer, file or other tool that is dropped on masonry or on a ferrous surface is thus a hazard unless the tool is made of non-sparking material. For this reason, portable electrical equipment is usually made from aluminum or other material that will not produce sparks if the equipment is dropped.

Electrical safety, therefore, is of crucial importance. The electrical installation must prevent accidental ignition of flammable liquids, vapors and dusts released to the atmosphere. In addition, since much of this equipment is used outdoors or in corrosive atmospheres, the material and finish must be such that maintenance costs and shutdowns are minimized.

B. Combustion Principles.

Three basic conditions must be satisfied for a fire or explosion to occur:

1. A flammable liquid, vapor or combustible dust must be present in sufficient quantity.
2. The flammable liquid, vapor, or combustible dust must be mixed with air or oxygen in the proportions required to produce an explosive mixture.
3. A source of energy must be applied to the explosive mixture.

In applying these principles, the quantity of the flammable liquid or vapor that may be liberated and its physical characteristics must be recognized. For instance, lighter-than-air gases diffuse into the atmosphere so readily that, except in enclosed spaces, they may not produce hazardous mixtures in areas close to electrical installations.

Vapors from flammable liquids also have a natural tendency to disperse into the atmosphere, and rapidly become diluted to concentrations below the lower limit of the flammable (explosive) range, particularly when the air is moving.

The probability that the gas concentration may be above the upper limit of the explosive range does not afford any degree of safety, as the concentration must first pass through the explosive range to reach the upper limit.

C. Evaluation of Hazardous Areas.

Each area that contains gases or dusts that are considered hazardous must be carefully evaluated to make certain the correct electrical equipment is selected. Many hazardous atmospheres are Class I, Group D, or Class II, Group G. However, certain areas may involve other groups, particularly Class I, Groups B and C. Conformity with the National Electric Code requires use of fittings and enclosures approved for the specific hazardous gas or dust involved.

For Class I and Class II equipment see the Crouse-Hinds Construction Materials Catalog or your Crouse-Hinds field representative.

D. Intrinsically Safe Equipment.

The use of intrinsically safe equipment is primarily limited to process control instrumentation, since these electrical systems lend themselves to the low energy requirements. The NFPA 493-1969 provides information on the design, evaluation, and installation of this equipment. This document defines intrinsically safe equipment and wiring as:

Equipment and wiring that are incapable of releasing sufficient electrical energy under normal or abnormal conditions to cause ignition of a specific hazardous atmospheric mixture in its most easily ignited concentration.

Underwriters Laboratories, Inc. & Factory Mutual have several devices in this category. The equipment and its associated wiring must be installed so they are positively separated from the non-intrinsically safe circuits. Induced voltages could defeat the concept of intrinsically safe circuits.

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II. Prevention of External Ignition and Explosion

E. Enclosures for Class I, Divisions 1 and 2 Conditions.

In both Division 1 and 2 of Class I locations, conventional relays, contactors and switches incorporating metal-to-metal contacts must be enclosed in explosion-proof housings.

By definition, enclosure for these locations must prevent the ignition of an explosive gas or vapor that may surround it. In other words, an explosion inside the enclosure must be prevented from starting a larger explosion on the outside.

Adequate strength is one requirement for such an enclosure. In most hazardous location designs for Class I, Divisions 1 & 2, a safety factor of 4 is used; i.e., the item must withstand a hydrostatic test of four times the maximum pressure from an explosion within the enclosure.

In addition to being strong, the enclosure must be "flame-tight." This term does not imply that the enclosure is hermetically sealed but rather that the joints or flanges are held within narrow U/L tolerances. These carefully machined joints cool the hot gases resulting from an internal explosion so that by the time they reach the outside hazardous atmosphere, they are too cool to effect ignition.

The strains and stresses caused by internal explosive pressures are illustrated in fig. 1. Dotted lines indicate shape that a rectangular enclosure strives to attain under these conditions. Openings in an enclosure for these applications can be threaded-joint type (fig. 2) or ground-joint type (fig. 3).

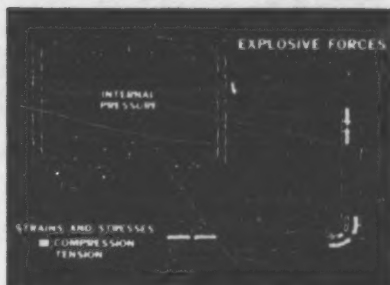


Fig. 1. Explosive forces.



Fig. 2. Threaded joint opening.



Fig. 3. Ground joint opening.

F. Purging/Pressurization Systems.

Purging/Pressurization Systems permit the safe operation of electrical equipment under conditions of hazard for which approved equipment may not be commercially available.

For instance, most switchgear units and many large-size motors do not come in designs approved for Class I, Groups A and B.

Whether cast enclosures for hazardous locations or sheet metal enclosures with pressurization should be used is mainly a question of economics, if both types are available. As a typical example, if an installation had many electronic instruments that could be enclosed in a single sheet-metal enclosure, the installation would lend itself to the Purging/Pressurization System. However, if the instruments, due to their nature, had to be installed in separate enclosures, then the cast, hazardous location housing would almost invariably prove more economical.

Pressurized enclosures require:

- A source of clean air or inert gas.
- A compressor to maintain the required pressure on the system.
- Pressure control valves, to prevent the power from being applied before the cases have been purged, and to de-energize the system should pressure fall below a safe value.

In addition, door-interlock switches are required to prevent access to the equipment while the circuits are energized. It can readily be seen that all of these accessories can add up to a considerable expenditure.

For a detailed description of Purging/Pressurizing Systems see NFPA Bulletin 496 titled "Purged and Pressurized Enclosures for Electrical Equipment 1974". Or refer to the Canadian Electrical Code article entitled "A Suggested Method for Air Pressurizing Electrical Wiring Systems and Equipment in Class I Hazardous Locations, Appendix H, Rule 18-026, CEC Part I".

Crouse-Hinds Code Digest

I. Classification of Hazardous Atmospheres

Table I

Summary of Hazardous Atmospheres

(Based on National Electric
Code and U/L)

Class	Division	Group	Typical atmosphere/ignition temps.	Devices covered	Temperature measured	Limiting value
I Gases, vapors	1 Normally hazardous	A	acetylene (305C, 581F)	All electrical devices and wiring	Maximum external temperature in 40C ambient	See Sect. 500-2 of NEC
		B	butadiene ¹ (420C, 788F) ethylene oxide ² (429C, 804F) hydrogen (400C, 752F) manufactured gases containing more than 30% hydrogen (by volume) propylene oxide ³ (449C, 840F)			
		C	acetaldehyde (175C, 347F) cyclopropane (500C, 932F) diethyl ether (160C, 320F) ethylene (490C, 914F) unsymmetrical dimethyl hydrazine (UDMH 1, 1-dimethyl hydrazine) (249C, 480F)			
		D	acetone (465C, 869F) acrylonitrile (481C, 898F) ammonia ⁴ (61C, 1204F) benzene (56C, 1040F) butane (405C, 761F) 1-butanol (butyl alcohol) (385C, 689F) 2-butanol (secondary butyl alcohol) (405C, 761F) n-butyl acetate (425C, 797F) isobutyl acetate (421C, 790F) ethane (515C, 959F) ethanol (ethyl alcohol) (356C, 669F) ethyl acetate (427C, 800F) ethylene dichloride (413C, 775F) gasoline (56-80 octane: 280C, 536F) (100 octane: 456C, 853F) heptanes (280C, 536F) hexanes (225C, 437F) isoprene (220C, 428F) methane (natural gas) (482 to 832C, 900 to 1170F) methanol (methyl alcohol) (385C, 725F) 3-methyl-1-butanol (isoamyl alcohol) (350C, 662F) methyl ethyl ketone (516C, 960F) methyl isobutyl ketone (460C, 860F) 2-methyl-1-propanol (isobutyl alcohol) (427C, 800F) 2-methyl-2-propanol (tertiary butyl alcohol) (480C, 896F) petroleum naphtha ⁴ (280C, 550F) octanes (220C, 428F) pentanes (280C, 500F) 1-pentanol (amyl alcohol) (300C, 572F) propane (450C, 842F) 1-propanol (propyl alcohol) (440C, 824F) 2-propanol (isopropyl alcohol) (399C, 750F) propylene (460C, 860F) styrene (490C, 914F) toluene (480C, 896F) vinyl acetate (427C, 800F) vinyl chloride (472C, 882F) xylenes (530C, 986F)			

I. Classification of Hazardous Atmospheres

Crouse-Hinds Code Digest

Table I cont'd.

Table I cont'd.			Summary of Hazardous Atmospheres†	(Based on National Electrical Code)		
Class	Division	Group	Typical atmosphere/ignition temps.	Devices covered	Temperature measured	Limiting value
	2 Not normally hazardous	A B C D	Same as Division 1 Same as Division 1 Same as Division 1 Same as Division 1 (Not normally hazardous means that the gases aren't normally present.)	Lamps, resistors, coils, etc., other than arcing devices. (see Div. 1)	Max. internal or external temp. not to exceed the ignition temperature in degrees Celsius (°C) of the gas or vapor involved	See Sect. 500-2
II Combustible dusts	1 Normally hazardous	E	Metal dust, including aluminum, magnesium, and their commercial alloys, and other metals of similarly hazardous characteristics.	Devices not subject to overloads (switches, meters)	Max. external temp. in 40C ambient with a dust blanket	No overload: E-200C (392F) F-200C (392F) G-165C (329F)
		F	Carbon black, coal, coke dust with more than 8% volatile material.	Devices subject to overload (motors, transformers)		Possible overload: E, F, G—120C (248F) but not to exceed no-overload values at overload
		G	Flour, starch, grain dusts.			
	2 Not normally hazardous	G	Same as Division 1	Lighting fixtures	Max. external temp. under conditions of use	Group: G—165C(329F)
III Easily ignitable fibers and flyings	1, 2			Lighting fixtures	Max. external temp. under conditions of use	165C (329F)

¹ Group D equipment shall be permitted for this atmosphere if such equipment is isolated in accordance with Section 501-5(a) by sealing all conduit 1/2-inch size or larger.

² Group C equipment shall be permitted for this atmosphere if such equipment is isolated in accordance with Section 501-5(a) by sealing all conduit 1/2-inch size or larger.

³ For Classification of areas involving ammonia atmosphere, see Safety Code for Mechanical Refrigeration (ANSI B9.1-1971) and Safety Requirements for the Storage and Handling of Anhydrous Ammonia (ANSI K61.1-1972).

⁴ A saturated hydrocarbon mixture boiling in the range 20—135°C (68—275°F). Also known by the synonyms benzene, ligroin, petroleum ether or naphtha.

† For a complete list noting properties of flammable liquids, gases and solids refer to NFPA No. 325M-1969.

Appendix I

Hazardous Substances Used in Business and Industry

Crouse-Hinds Code Digest

Class I Group	Substance	Flash Point Degrees F	Flash Point Degrees C	Ignition Temp. Degrees F	Ignition Temp. Degrees C	Explosive Limits Per cent by Volume		Vapor Density (Air Equals 1.0)
						Lower	Upper	
C	acetaldehyde	-36	-38	347	175	4	60	1.5
D	acetone	0	-17	869	465	2.6	12.8	2.0
A	acetylene	gas	gas	581	305	2.5	100	0.9
D	acrylonitrile	32	0	898	481	3	17	1.8
D	ammonia	gas	gas	1204	651	16	25	0.6
D	benzene	12	-11	1040	560	1.3	7.1	2.8
B	butadiene	gas	gas	788	420	2	12	1.9
D	butane	gas	gas	761	405	1.9	8.5	2.0
D	1-butanol (butyl alcohol)	84	29	689	365	1.4	11.2	2.6
D	2-butanol (secondary butyl alcohol)	75	24	761	405	1.7 @ 212°F, 100°C	9.8 @ 212°F, 100°C	2.6
D	n-butyl acetate	72	22	797	425	1.7	7.6	4.0
C	cyclopropane	gas	gas	932	500	2.4	10.4	1.5
C	diethyl ether	-49	-45	320	160	1.9	36	2.6
D	ethane	gas	gas	959	515	3	12.5	1.0
D	ethanol (ethyl alcohol)	55	13	689	365	3.3	19	1.6
D	ethyl acetate	24	-4	800	427	2.2	11	3.0
C	ethylene	gas	gas	914	490	2.7	36	1.0
D	ethylene dichloride	56	13	775	413	6.2	16	3.4
B	ethylene oxide	<0	<-17	804	429	3.6	100	1.5
D	gasoline:							
	55-60 octane	-45	-48	536	280	1.4	7.6	3-4
	100 octane	-36	-38	853	456	1.4	7.4	3-4
D	heptanes	25-32	-4 to 0	419-536	215-280	1.05	6.7	3.5
D	hexanes	-7	-22	437	225	1.1	7.5	3.0
B	hydrogen	gas	gas	752	400	4.0	75	0.1
D	isobutyl acetate	64	18	790	421	2.4	10.5	4.0
D	isoprene	-65	-54	428	220	2	9	2.4
D	methane (marsh gas)	gas	gas	1004	528	5	15	0.6
D	methanol (methyl alcohol)	52	11	725	385	6.7	36	1.1
D	3-methyl-1-butanol (isamyl alcohol)	109	43	662	350	1.2	9	3.0
D	methyl ethyl ketone	21	-6	960	516	1.8	10	2.5
D	methyl isobutyl ketone	73	23	880	480	1.4	7.5	3.5
D	2-methyl-1-propanol (isobutyl alcohol)	82	28	800	427	1.2 @ 212°F, 100°C	10.9 @ 212°F, 100°C	2.6
D	2-methyl-2-propanol (tertiary butyl alcohol)	52	-11	896	480	2.4	8	2.6
D	octanes	56	13	428	220	1.0	6.5	3.9
D	pentanes	<-40	<-40	500	260	1.5	7.8	2.5
D	1-pentanol (amyl alcohol)	91	33	572	300	1.2	10 @ 212°F, 100°C	3.0
D	petroleum naphtha	<0	<-17	550	288	1.1	5.9	2.5
D	propane	gas	gas	842	450	2.2	9.5	1.6
D	1-propanol (propyl alcohol)	77	25	824	440	2.1	13.5	2.1
D	2-propanol (isopropyl alcohol)	53	12	750	399	2	12	2.1
D	propylene	gas	gas	860	460	2	11.1	1.5
B	propylene oxide	-35	-37			2.6	37	2.0
D	styrene	90	32	840	449	1.1	6.1	3.6
D	toluene	40	4	914	490	1.2	7.1	3.1
C	unsymmetrical dimethyl hydrazine (UDMH 1, 1-dimethyl hydrazine)			896	480			
		5	-15	480	249	2	95	2.0
D	vinyl acetate	18	-8	800	427	2.6	13.4	3.0
D	vinyl chloride	gas	gas	882	472	3.6	33	2.2
D	xylene	81	27	986	530	1.1	7	3.7

Article 513 Aircraft Hangars

Crouse-Hinds Code Digest

513-6. Stanchions, Rostrums, and Docks.

(a) IN HAZARDOUS LOCATION. Electric wiring, outlets, and equipment (including lamps) on or attached to stanchions, rostrums, or docks that are located or likely to be located in a hazardous location as defined in Section 513-2(c) shall comply with the requirements for Class I, Division 2 locations.

(b) NOT IN HAZARDOUS LOCATION. Where stanchions, rostrums, or docks are not located or likely to be located in a hazardous location as defined in Section 513-2(c), wiring and equipment shall comply with Sections 513-4 and 513-5, except that such wiring and equipment not more than 18 inches above the floor in any position shall comply with (a) above. Receptacles and attachment plugs shall be locking type that will not readily disconnect.

(c) MOBILE TYPE. Mobile stanchions with electric equipment complying with (b) above shall carry at least one permanently affixed warning sign to read: "WARNING—KEEP 5 FEET CLEAR OF AIRCRAFT ENGINES AND FUEL TANK AREAS."

513-7. Sealing.

Approved seals shall be provided in accordance with Section 501-5. Sealing requirements specified in Sections 501-5(a)(4) and 501-5(b)(2) shall apply to horizontal as well as to vertical boundaries of the defined hazardous locations. Raceways embedded in a masonry floor or buried beneath a floor shall be considered to be within the hazardous location above the floor where any connections or extensions lead into or through such location.

513-8. Aircraft Electrical Systems.

Aircraft electrical systems shall be de-energized when the aircraft is stored in a hangar, and, whenever possible, while the aircraft is undergoing maintenance.

513-9. Aircraft Battery—Charging and Equipment.

Aircraft batteries shall not be charged when installed in an aircraft located inside or partially inside a hangar.

Battery chargers and their control equipment shall not be located or operated within any of the hazardous areas defined

in Section 513-2, and shall preferably be located in a separate building or in an area such as described in Section 513-2(d). Mobile chargers shall carry at least one permanently affixed warning sign to read: "WARNING—KEEP 5 FEET CLEAR OF AIRCRAFT ENGINES AND FUEL TANK AREAS." Tables, racks, trays, and wiring shall not be located within a hazardous location, and, in addition, shall comply with Article 480.

513-10. External Power Sources for Energizing Aircraft.

(a) NOT LESS THAN 18 INCHES ABOVE FLOOR. Aircraft energizers shall be so designed and mounted that all electric equipment and fixed wiring will be at least 18 inches above floor level and shall not be operated in a hazardous location as defined in Section 513-2(c).

(b) MARKING FOR MOBILE UNITS. Mobile energizers shall carry at least one permanently affixed warning sign to read: "WARNING—KEEP 5 FEET CLEAR OF AIRCRAFT ENGINES AND FUEL TANK AREAS."

(c) CORDS. Flexible cords for aircraft energizers and ground support equipment shall be approved for the type of service and extra-hard usage and shall include an equipment grounding conductor.

513-11. Mobile Servicing Equipment with Electric Components.

(a) GENERAL. Mobile servicing equipment

Recommended installation for aircraft hangars

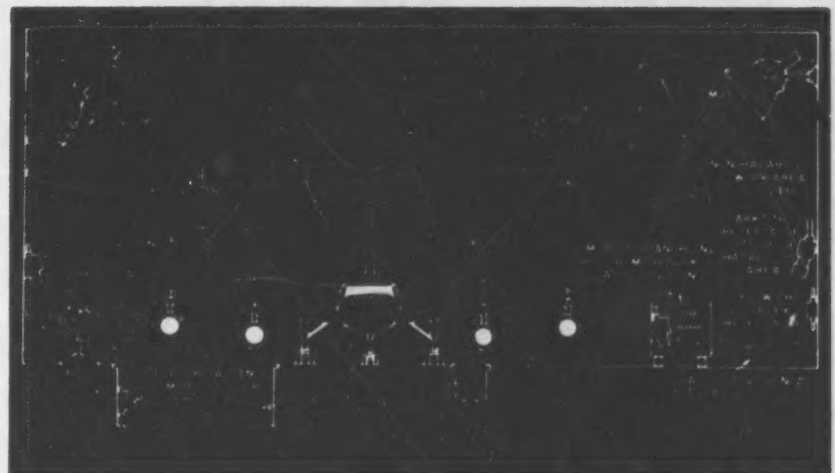
(such as vacuum cleaners, air compressors, air movers, etc.) having electric wiring and equipment not suitable for Class I, Division 2 locations shall be so designed and mounted that all such fixed wiring and equipment will be at least 18 inches above the floor. Such mobile equipment shall not be operated within the hazardous location defined in Section 513-2(c) and shall carry at least one permanently affixed warning sign to read: "WARNING—KEEP 5 FEET CLEAR OF AIRCRAFT ENGINES AND FUEL TANK AREAS."

(b) CORDS AND CONNECTORS. Flexible cords for mobile equipment shall be suitable for the type of service and approved for extra-hard usage, and shall include an equipment grounding conductor. Attachment plugs and receptacles shall be approved for the location in which they are installed, and shall provide for connection of the grounding conductor to the raceway system.

(c) RESTRICTED USE. Equipment not suitable for Class I, Division 2 locations shall not be operated in locations where maintenance operations likely to release flammable liquids or vapors are in progress.

513-12. Grounding.

All metal raceways and all noncurrent-carrying metal portions of fixed or portable equipment, regardless of voltage, shall be grounded as provided in Article 250.



Article 514 **Gasoline** **Dispensing** **and Service** **Stations**

Crouse-Hinds **Code Digest**



▲ Pole standard within 20 ft. horizontally from any dispensing island or pump, or from any tank fill-pipe or tank vent-pipe is Class I, Division 2. See 514-2(b).

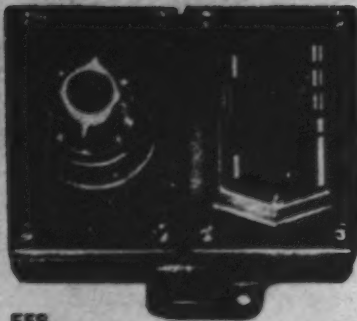
▲ A building less than 20 ft. from any island, pump, tank fill-pipe, or tank vent-pipe is a Class I, Division 2 location up to 18 inches above grade.

Note
 If a building is over 20 feet from any island, pump, tank fill-pipe, or tank vent-pipe it is not a hazardous location. But in either case seals must be placed in all underground conduits to prevent explosions in conduits from reaching panelboard. See 514-6 (a) and (b).

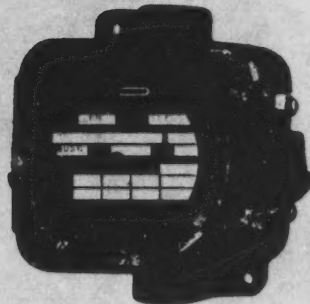


Article 515 Bulk-Storage Plants

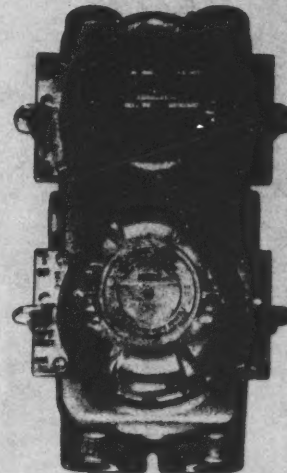
Crouse-Hinds Code Digest



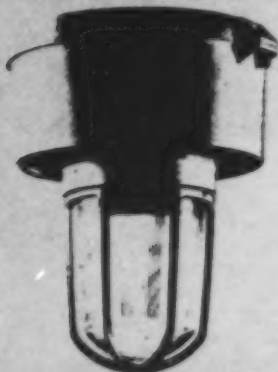
EFS
Push button station and pilot light



GUSC Enclosure with switch circuit
breaker or manual starter



GUSC
Combination manual starter and circuit
breaker enclosure



VMV Mercury vapor lighting fixture



VXHT Incandescent lighting fixture

Note: The VMV and VDC fixtures are suitable for Class I, Div. 2. All other enclosures on these two pages are suitable for use in Class I, Division 1 locations in bulk storage plants.



(c) For spraying operations confined to an enclosed spray booth, the space within 3 feet in all directions from any openings in the spray booth.

(5) All space within the room but beyond the limits for Class I, Division 1 as defined in Section 516-2(a) for dip tanks and drain boards, and for other hazardous operations.

(c) ADJACENT LOCATIONS. Adjacent locations that are cut off from the defined hazardous locations by tight partitions without communicating openings, and within which hazardous vapors are not likely to be released, shall be classified as nonhazardous unless the authority having jurisdiction judges otherwise.

(d) NONHAZARDOUS LOCATIONS. Locations utilizing drying, curing, or fusion apparatus and provided with positive mechanical ventilation adequate to prevent formation of flammable concentrations of vapors, and provided with effective interlocks to de-energize all electric equipment (other than equipment approved for Class I locations) in case the ventilating equipment is inoperative, may be classified as nonhazardous where the authority having jurisdiction so judges.

For further information regarding safeguards, see Ovens and Furnaces, Design, Location and Equipment (NFPA No. 86A-1973).

516-3. Wiring and Equipment in Hazardous Locations.

(a) WIRING AND EQUIPMENT—VAPORS. All electric wiring and equipment within the hazardous location (containing vapor only—not residues) defined in Section 516-2 shall comply with the applicable provisions of Article 501.

(b) WIRING AND EQUIPMENT—VAPORS AND RESIDUES. Unless approved for both readily ignitable deposits and the flammable vapor location, no electric equipment shall be installed or used where it may be subject to hazardous accumulations of readily ignitable deposits or residues, as the susceptibility to spontaneous heating and ignition of some residues may be greatly increased at temperatures above normal. Type MI cable and wiring in threaded rigid metal conduit may be installed in such locations, if the explosion-proof boxes or fittings contain no taps, splices, or terminal connections that may possibly become loose in service and thereby cause abnormal temperatures on external surfaces of boxes or fittings.

(c) ILLUMINATION. Illumination of readily ignitable areas through panels of glass or other transparent or translucent material shall be permitted only if it complies with the following: (1) fixed lighting units are used as the source of illumination; (2) the panel effectively isolates the hazardous location from the area in which

the lighting unit is located; (3) the lighting unit is approved for its specific location; (4) the panel is of a material or is so protected that breakage will be unlikely; and (5) the arrangement is such that normal accumulations of hazardous residue on the surface of the panel will not be raised to a dangerous temperature by radiation or conduction from the source of illumination.

(d) PORTABLE EQUIPMENT. Portable electric lamps or other utilization equipment shall not be used within a hazardous location during operation of the finishing process. When such lamps or utilization equipment are used during cleaning or repairing operations, they shall be of a type approved for Class I, Group D, Division 1 locations, and all exposed metal parts shall be effectively grounded.

(e) ELECTROSTATIC EQUIPMENT. Electrostatic spraying or detearing equipment shall be installed and used only as provided in Section 516-4.

For further information, see NFPA Standard for Spray Application Using Flammable and Combustible Materials (NFPA No. 33-1973).

516-4. Fixed Electrostatic Equipment.

This Section shall apply to any equipment using electrostatically charged elements for the atomization, charging, and/or



Appendix V

Diagram for Class I, Div. 1 Lighting Installation

Crouse-Hinds Code Digest



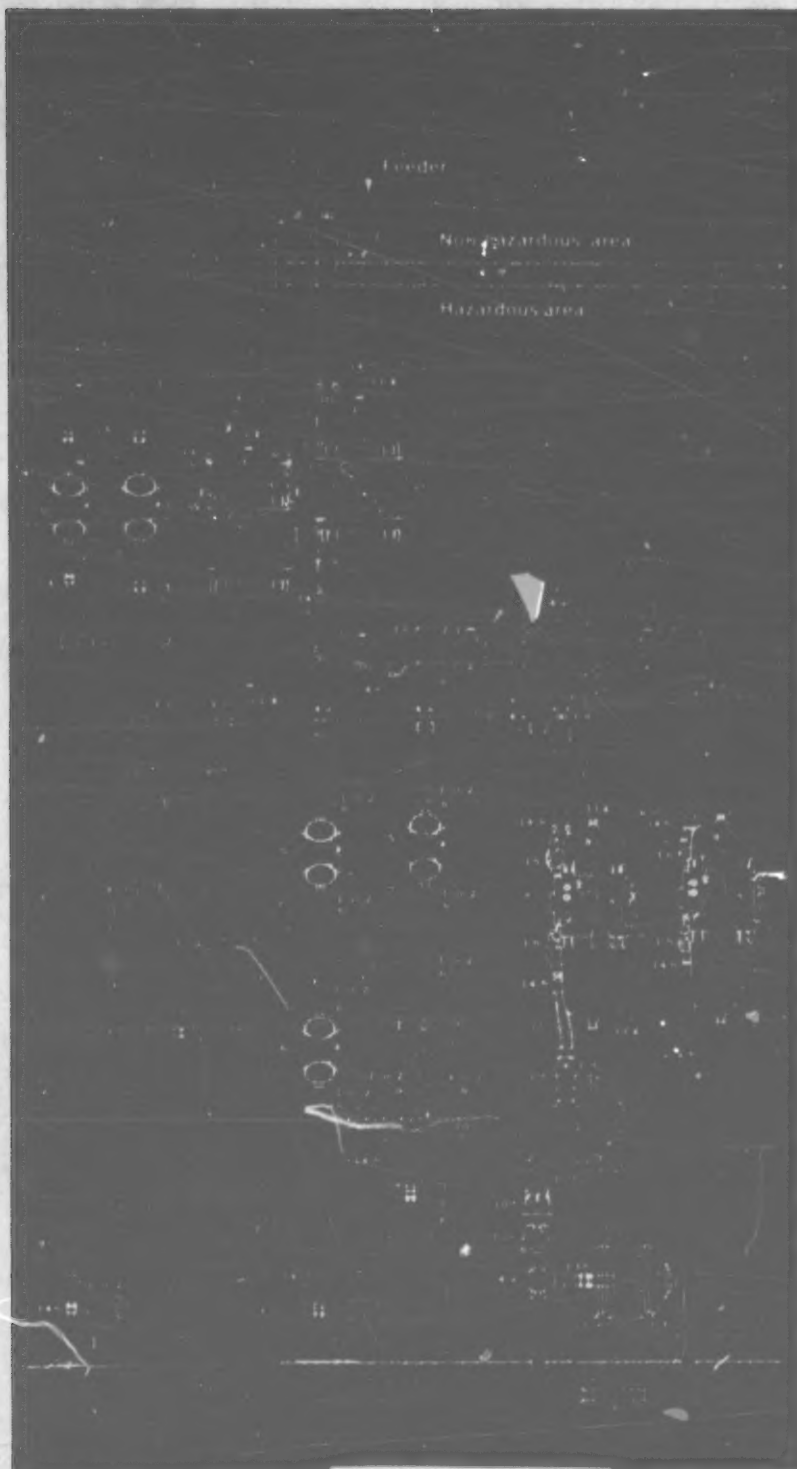
Key to Numerals

- 1 Sealing fitting. EYS for horizontal or vertical.
- 2 Sealing fitting. EZS for vertical or horizontal conduit.
- 3 Circuit breaker. Type EPC.
- 4 Panelboard. EDP. Branch circuits are factory sealed. No seals required in mains or branches unless 2" or over in size.
- 5 Junction box. Series GUA, GUB, GUJ, have threaded covers. Series CPS has ground flat surface covers.
- 6 Fixture hanger. EFHC, GUAC or EFH.
- 7 Lighting fixture. EV series.
- 8 Flexible fixture support. ECGH or EFH.
- 9 Fluorescent fixture. EVF.
- 10 Float switch. EMS.
- 11 Signal. ETH horns and sirens. ESR Bells.
- 12 Visularm EKP.
- 13 Plug receptacle. CES-delayed action.
- 14 Plug receptacle. FSQ. Interlocked with switch.
- 15 Breather. ECD.
- 16 Drain. ECD.
- 17 Union. UNY.
- 18 Switch. Series EFS.
- 19 Manual line starter. FLF.
- 20 Manual line starter. GUSC.
- 21 Motors. explosion-proof.

National Electrical Code References

- a Par. 501-5a-4. Seal required where conduit passes from hazardous to non-hazardous area.
- b Par. 501-5a-1. Seals required within 18 inches of all arcing devices.
- c Sec. 384-16. Circuit breaker or rating not greater than rating of panelboard required if supply conductors have overcurrent protection over 200 amperes.
- d Par. 501-5a-2. Seals required if conduit is 2 inches or larger.
- e Par. 501-8a. All arcing devices must be explosion-proof.
- f Par. 501-4a. All boxes must be explosion-proof and threaded for rigid conduit.
- g Par. 501-9a-4. All boxes and fittings for support of lighting fixtures must be approved for the purpose.
- h Par. 501-9a-1. All lighting fixtures fixed or portable must be explosion-proof.
- i Par. 501-9a-3. Pendant fixture stems must be threaded rigid conduit or approved flexible connector. Rigid stems if over 12 inches must have flexible connector, or must be braced.
- j Sec. 501-14a. All signal circuits irrespective of voltage must be approved for Class I location.
- k Sec. 501-12. Receptacles and plugs must be explosion-proof and provide grounding connections for portable equipment.
- l Par. 501-5f. Breathers and drains needed in all humid locations.
- m Par. 501-4a. All joints and fittings must be explosion-proof.
- n Par. 501-8a. Motor must be suitable for Class I.
- p Art. 430. Motor overcurrent protection.

**Diagram
for Class I, Div. 1
Power
Installation**



Key to Numerals

- 1 Sealing fitting. EYS for horizontal or vertical.
- 2 Sealing fitting. EZS for vertical or horizontal conduits.
- 3 Circuit breaker EPC.
- 4 Junction box series GUA, GUB and GUJ have threaded covers. Series CPS and Type LBH have ground flat surface covers.
- 5 Circuit breaker FLB.
- 6 Manual line starter FLF.
- 7 Magnetic line starter GUB.
- 8 Combination circuit breaker and line starter EPC.
- 9 Switch or motor starter. Series EFS or GUSC.
- 10 Push button station. Series EFS or OFC.
- 11 Breather. ECD.
- 12 Drain. ECD.
- 13 Union. UNF.
- 14 Union. UNY.
- 15 Flexible coupling. ECH.
- 16 Plug receptacle. CES. Factory sealed.
- 17 Motor for hazardous location.

National Electrical Code References

- a Par. 501-5a-3. Seals required where conduits pass from hazardous to non-hazardous area.
- b Par. 501-5a-1. Seals required within 18 inches of all arcing devices.
- c Art. 430 should be studied for detailed requirements for conductors, motor feeders, motor feeder and motor branch circuit protection, motor overcurrent protection, motor controllers and motor disconnecting means.
- d Par. 501-5a-2. Seals required if conduit is 2 inches or larger in size.
- e Par. 501-4a. All boxes must be explosion-proof and threaded for rigid conduit.
- f Par. 501-6a. Push button stations must be explosion-proof.
- g Par. 501-5d. Breathers and drains needed in all humid locations.
- h Par. 501-4a. All joints and fittings must be explosion-proof.
- i Par. 501-4a. Flexible connections must be explosion-proof.
- j Sec. 501-12. Receptacles and plugs must be explosion-proof, and provide grounding connections for portable devices.

Appendix VI

Diagram for Class I, Div. 2 Power and Lighting Installation

Crouse-Hinds Code Digest



Key to Numerals

- 1 Sealing fitting. EYS for horizontal or vertical.
- 2 Sealing fitting. EZS for vertical or horizontal conduits.
- 3 Circuit breaker. Type EPC.
- 4 Panelboard. D2PB, N2PB. Branch circuits are factory sealed.
- 8 Junction box or conduit fitting. NJB, obround.
- 6 Fixture hanger. AHG, GS, UNJ.
- 7 Lighting fixture. VMV (Relamp Champ).
- 8 Flexible fixture support.
- 9 Handlamp. EVH.
- 10 Float switch. EMS.
- 11 Signal. ETH horns and sirens. ESR Bells.
- 12 Visularm EKP.
- 13 Plug receptacle. CES-delayed action.
- 14 Plug receptacle. FSQ. Interlocked with switch.
- 16 Breather. ECD.
- 16 Drain. ECD.
- 17 Union. UNY.
- 18 Switch. Series EFS.
- 19 Manual line starter. FLF.
- 20 Manual line starter. GUSC.
- 21 Motors. Suitable for Class I locations.

National Electrical Code References

- a Par. 501-5b-2. Seal required where conduit passes from hazardous to non-hazardous area.
- b Par. 501-5b-1. Seals required within 18 inches of all arcing devices.
- c Sec. 384-16. Circuit breaker or rating not greater than rating of panelboard required if supply conductors have overcurrent protection over 200 amperes.
- d Par. 501-9b-2. All fixed lighting fixtures shall be enclosed and gasketed and not exceed ignition temperature of the gas.
- e Par. 501-5b1. All arcing devices must be explosion-proof.
- f Par. 501-4b. All boxes must be threaded for rigid conduit.
- g Par. 501-9b-4. All boxes and fittings for support of lighting fixtures must be approved for the purpose.
- h Par. 501-9b-1. All portable lighting fixtures must be explosion-proof.
- i Par. 501-9b-3. Pendant fixture stems must be threaded rigid conduit or approved flexible connector. Rigid stems if over 12 inches must have flexible connector, or must be braced.
- j Sec. 501-14-b. All signalling equipment must be approved for Class I location.
- k Sec. 501-12. Receptacles and plugs must be explosion-proof and provide grounding connections for portable equipment.
- l Par. 501-5f. Breathers and drains needed in all humid locations.
- m Par. 501-4b. All joints and fittings are not required to be explosion-proof.
- n Par. 501-8b. Motor shall be suitable for Div. 2.
- p Art. 430. Motor overcurrent protection.

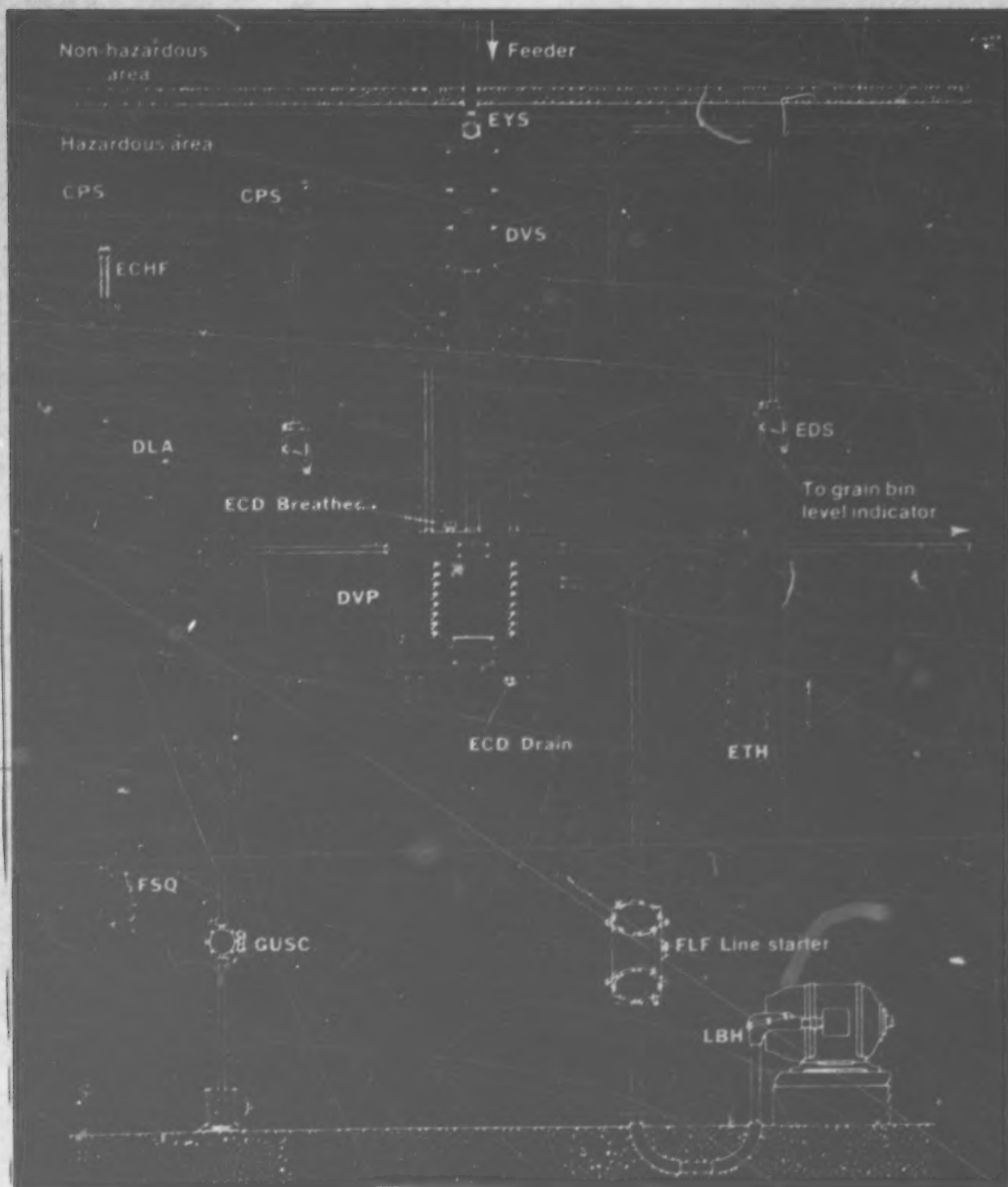
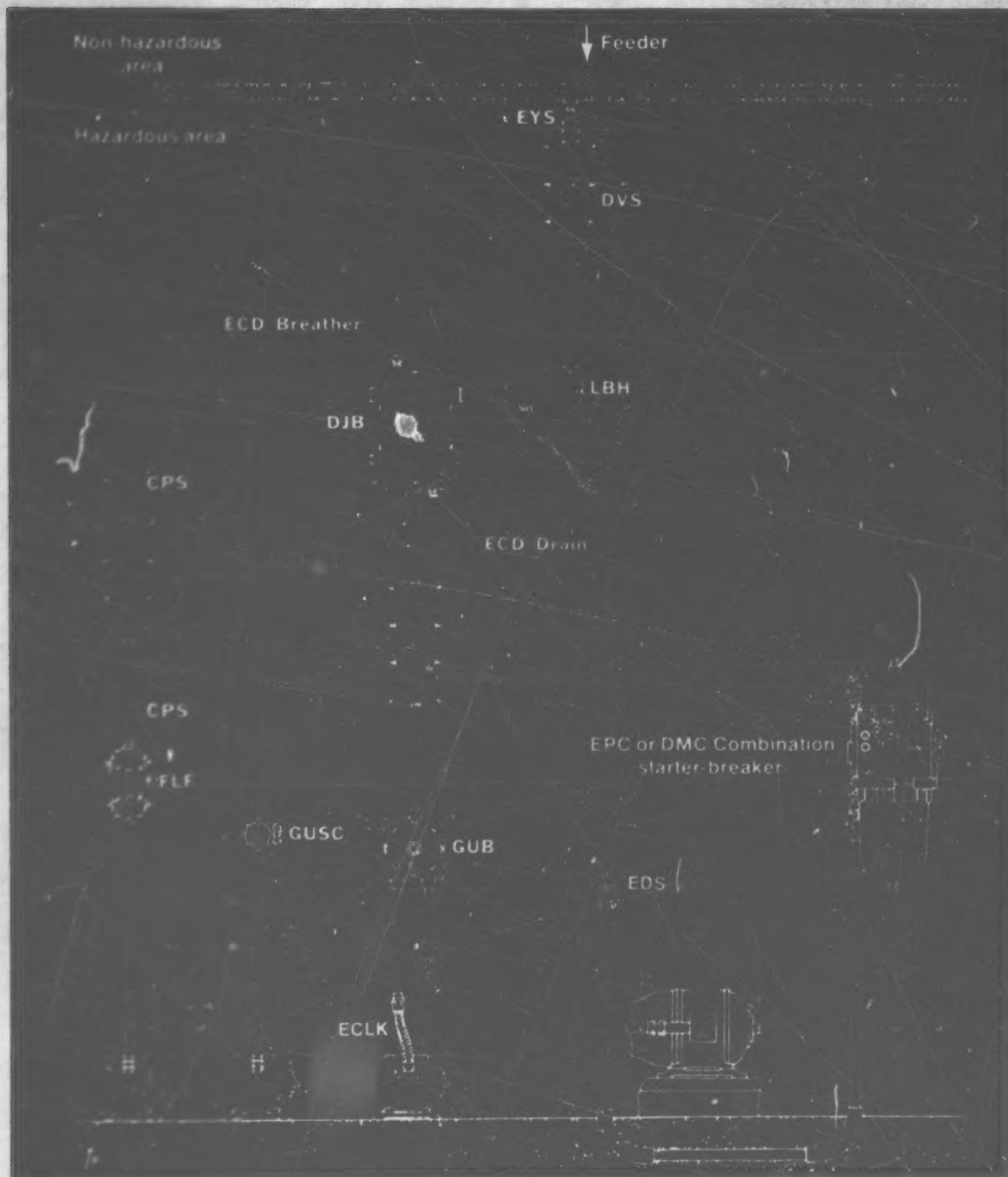


Diagram
for Class II
Power
Installation

Crouse-Hinds
Code Digest



Crouse-Hinds Code Digest

Appendix IX

"Quick-Selector" Electrical Equipment for Hazardous Locations

Note: Not all types listed are suitable for use in all four groups of Class I hazardous locations. Consult catalog listing pages for applicable classes and groups.

Note: Not all types listed are suitable for use in all four groups of Class I hazardous locations. Consult catalog listing pages for applicable classes and groups.							
	Class I Div. 1	Class I Div. 2	Class II Div. 1		Class II Div. 2 (Group G only)	Class III Div. 1	Class III Div. 2
			Group E & F G				
Conduit outlet bodies and junction boxes	CPS EJB EKC GUB GUJ EAB EJH GUA GUF LBH	Form 7 Series, etc., W Series	CPS EJB EKC GUB GUJ EAB EJH GUA GUF LBH	Same if splices, taps, etc.	Form 7 Series, etc., W Series		
Switches							EDS, EFD, EFS, FLS, FSPC, GUSC, OFC
Panelboards	EDP ESPB GUSC	EDP ESPB GUSC D2PB	DLP, DVP				
Lighting fixtures	EV EVAM EVF Hazard-Gard RCDE	Vaporgard V Series VDB VMV VMVC VMVM VMVS FVN	DL DLAM EVF FDV		Vaporgard V Series VDB VMV VMVC VMVM VMVS FVN		
Fixture hangers	COUP CPS EAHC EC EFHC GUA	AHG EC GS UNE UNH UNJ UNJC	CPS EC EAHC EFHC GUA		AHG EC GS OSA	AHG AL EC GS OSA UNJ UNJC	
Plugs and receptacles	APJ, CES, CESD, CPH, CPP, CPS, EHS, ESW, BHR, BHP, DR, EHR, FP, FSQ, SRD, SP		Group G only APJ, BHR, BHP, DR, FP, FSQ, SRD, SP		Arktite Arktrol		
Interlocked plug receptacles	EPC, FSQ		Group G only FSQ, EPC, DBR			FSQ, EPC, DBR	
Control stations and pilot lights							EDS, EFD, EFS, EGP, EMP, EWC, OAC, OFC
Industrial control							BMC, EDS, EFD, EFS, EPC, EPCB, FLF, FSPC, GUB, GUSC, OFC
Circuit breakers	EDS, EFD, EPC, EPCB, FLB, GUSC		DVS, EDS, EFD, EPC, FLB, GUSC				
Telephones, instruments and signals	ECT, EKP, EMH, ESR, ET Telephones, ETH, GUB (plus WH (A.C. only) for Class II, Div. 2 and Class III, Div. 1 and 2)						

NAME _____

LESSON C-8

DATE _____

WORKSHEET

HAZARDOUS LOCATIONS

1. Do Articles 500 - 517 apply to hazardous locations if intrinsically safe equipment and wiring is used? Yes/No NO. Give the N.E. Code Section to prove your answer. 500-1
2. Define "intrinsically safe" equipment. EQUIPMENT AND WIRING INCAPABLE OF RELEASING SUFFICIENT ELECTRICAL ENERGY UNDER NORMAL OR ABNORMAL CONDITIONS TO CAUSE IGNITION
3. Define the three classes of hazardous locations:
 - I. FLAMMABLE GASES OR VAPORS
 - II. COMBUSTIBLE DUST
 - III. EASILY IGNITABLE FIBERS OR FLYINGS
4. List the class and group classification for the following areas:

	CLASS	DIVISION	GROUP
(a) Ethylene	1		C
(b) Starch	2		G
(c) Gasoline	1		D
(d) Acetylene	1		A
(e) Benzol	1		D
(f) Hydrogen	1		B
(g) Coal	2		F
(h) Aluminum Dust	2		E
(i) Lacquer Solvent Vapors	1		D
(j) Flour	2		G
(k) Rayon	3	I	NO LISTING

5. Where may hazardous materials be found in a Division 1 area?
FREELY PRESENT IN AIR
6. Where may hazardous materials be found in a Division 2 area?
NORMALLY CONFINED TO CONTAINERS
7. What type hazardous location requires the installation of wiring in threaded rigid metal conduit with explosion-proof fitting or Type "MI" cable? CLASS I, DIVISION 1
8. What type wiring installation is required in a Class III, Division I location? SAME AS CLASS II LOCATION

9. What type wiring installation is required in a Class II, Division I location? THREADED RIGID METAL CONDUIT OR MI CABLE,
THREADED FITTINGS
10. Electrical metallic tubing may be used in Class II, Division II location.
11. What type wiring installation is required in a Class I, Division II location? RIGID METAL CONDUIT, SEALS, THREADED FITTINGS, OR
TYPE MI CABLE
12. Where it is impractical to make a threaded joint tight, BONDING
JUMPERS shall be utilized.
13. What is the intent of Article 500 through 503? TO REQUIRE A FORM
OF CONSTRUCTION OF EQUIPMENT AND OF INSTALLATION THAT WILL INSURE
SAFE PERFORMANCE UNDER CONDITIONS OF PROPER USE AND
MAINTENANCE
14. Where are the definitions of "approved," "explosion-proof," and "dust-ignition proof" found in the N. E. Code?
ARTICLE 100 & SECTION 502-1
15. What markings will show on "approved" equipment to be used in hazardous locations?
- (a) CLASS
- (b) GROUP
- (c) OPERATING TEMPERATURE OR TEMPERATURE RANGE
16. The temperature range of an item of equipment is based on an ambient of 40° C.

CLASS I INSTALLATIONS

(HAZARDOUS LOCATIONS)

DESIRED RESULTS:

To acquaint the apprentice with the safety devices used in hazardous locations called Class I.

INTRODUCTION:

The next three lessons are concerned with locations that, because of their nature, call for higher standards with respect to materials or for methods of installation, than are thought necessary in the general run of electrical wiring.

Class I deals with activities in which fire or explosion may result from gases or vapor.

METHODS OF REDUCING HAZARDS:

1. Placing seals between safe areas and perilous ones. Seal fittings are inserted in conduits to arrest sparks, using a suitable compound to accomplish the purpose. In some areas, where non-conductive dusts are present, a length of conduit may serve in place of the fitting.
2. Sparking devices are sealed off from runs of conduit which enter them. In some cases, the safety rule is met by placing sparking contacts in an oil bath or a hermetically sealed chamber.
3. Rigid conduit or mineral-insulated cable are prescribed as the only acceptable wiring methods in the majority of hazardous locations. Continued grounding must be assured by means of bonding and not by locknuts and bushings. Fittings must be explosion proof, dust-ignition proof, depending upon the nature of the particular hazard.
4. Motors within the scope of Class I, Division I, must be explosion proof. Under Class I, Division 2, standard motors can be used if they have no sliding contacts. Motors within Class II and III must be totally enclosed or pipe ventilated.

Extension cords are prohibited in certain occupancies, and allowed in others only if approved for the particular service.

ESPECIALLY LISTED OCCUPANCIES:

1. In commercial garages, the NEC requires that plug receptacles within 18 inches of the floor be treated as subject to Class I, Division 2, requirements.
2. Unventilated garage pits, aircraft hangars, and gasoline dispensing islands are devoted as Class I, Division 1, to a height of 4 feet above grade.
3. Finishing processes, where paints, lacquers, or other flammable coatings are applied by spraying, dipping, brushing, or similar means, must be carried out under prescribed safeguards for electrical wiring and equipment. Of particular interest here, are electrostatic units which incorporate high-voltage transformers.
4. Anesthetizing locations of hospitals are deemed to be Class I, Division 1, to a height of 5 feet above the floor. Gas storage rooms are in the same designation.

Special rules apply to lighting and surgical equipment within the operating room.

5. Theaters and motion picture studios are given adequate consideration in the NEC.

Fires may occur suddenly from temporary wiring in connection with stage scenery, projection room equipment, arc lamps, and other portable devices.

6. Radio or television studios and receiving stations must be guarded from danger offered by high-voltage electronic wiring systems or equipment.

VISUAL AIDS:

Appropriate films models if available.

APPLICATION:

The students should answer the questions on the Assignment Sheet.

CHECKING AND FOLLOW-UP:

Check the answers on the sheets and return to the students for correction and placing in workbooks.

NAME _____

LESSON C-9

DATE _____

WORKSHEET

CLASS I INSTALLATIONS

(HAZARDOUS LOCATIONS)

1. List two construction requirements for vaults containing transformers and capacitors not containing a liquid that will burn installed in Class I, Division 1 locations:
 - (a) CONFORM TO SECTION 501 (2-1)
 - (b) APPROVED FOR CLASS I LOCATION
2. Installation of transformers and capacitors in Class I, Division 2 locations requires only standard code requirement as covered in sections 450-21 to 450-25.
3. Rigid threaded METAL CONDUIT or Type MI cable shall be installed in Class I, Division 1 locations.
4. All boxes, fittings, and joints shall be THREADED and shall be EXPLOSION PROOF in Class I, Division 1 locations.
5. In Class I, Division 2 locations, Type MI cable or threaded RIGID METAL CONDUIT shall be installed.
6. What is the purpose of using seals? TO PREVENT PASSAGE OF GASES FROM ONE PART OF ELECTRICAL SYSTEM TO ANOTHER.
7. Seals shall not exceed 18 inches from enclosure in Class I, Division 1 locations.
8. Are seals required in conduits less than 2 inches diameter in Class I, Division 1 locations? YES
9. In conduits leaving Class I, Division 1 areas, seals may be installed either INSIDE or OUTSIDE the hazardous area.
10. If the seal is installed inside the hazardous area of a Class I, Division 1 location, there shall be no UNION, COUPLING, BOX, or FITTING in conduit between seal fitting and the point at which the conduit leaves the hazardous area.
11. Explosion- PROOF flexible motor fittings shall be used in Class I, Division 1 locations.

12. The thickness of compound in seal fittings shall not be less than 5/8 inch.
13. Splices and TAPS shall not be made in sealing fittings.
14. In Class I, Division 2 locations, a disconnecting switch may be of the GENERAL PURPOSE type.
15. List the two conditions under which a panelboard with a general purpose enclosure may be installed in a Class I, Division 2 area.
- (a) THE INTERRUPTION OF CURRENT OCCURS WITHIN A HERMETICALLY SEALED CHAMBER
- (b) THE CURRENT-INTERRUPTING CONTACTS ARE OIL IMMERSED
16. Flexible cord with a ground conductor may be used in Class I, Division I & II wiring.
17. Motors shall be EXPLOSION PROOF or POSITIVE PRESSURE type for Class I, Division 1 locations.
18. Lighting fixtures in Class I, Division 1 locations shall be approved as a COMPLETE assembly.
19. Stems for pendant fixtures in Class I, Divisions 1 and 2 locations shall not exceed 12 inches without permanent bracing.
20. List two required methods of protecting lighting fixtures in Class I, Division 1 areas:
- (a) BRACING - WITHIN 12 INCHES OF LOWER END OF STEM
- (b) FLEXIBILITY - FLEX NOT MORE THAN 12" FROM BOX OR FITTING
21. Flexible cords may be used for connection to portable LAMPS in Class I, Divisions 1 and 2 locations.
22. List two requirements for using receptacles in Class I, Divisions 1 and 2 locations:
- (a) PLUG DOES NOT INTERRUPT CURRENT
- (b) PLUG IS LOCKING AND GROUNDING TYPE

NAME _____

LESSON C-9

DATE _____

WORKSHEET

23. In Class I, Divisions 1 and 2 locations, conductor insulation shall be protected by a sheath of LEAD where vapors or liquids may collect on conductors.
24. All exposed non-current-carrying metal parts of electrical equipment shall be GROUNDING in Class I, Divisions 1 and 2 locations.
25. In Class I, Divisions 1 and 2, there shall be no EXPOSED live parts.
26. Grounding requirements in class I division I and II locations are (more or less) MORE restrictive than in article 250. These requirements are found in 501-16.

CLASS II INSTALLATIONS

(HAZARDOUS LOCATIONS)

DESIRED RESULTS:

To acquaint the apprentice with the safety devices used in hazardous locations, called Class II.

INTRODUCTION:

If approved electrical devices of high quality are used, but installed in a haphazard fashion and with no regard to the relation of one device to the other, the total load, or the hazardous operating conditions, the complete installation may be dangerous. It is necessary that standardized methods be set up which have been found in practice to be safe.

These standardized methods that experiment and experience have shown to be correct are set down in a form which has come to be known as the National Electrical Code. (NEC).

Class II is concerned with the possibility of fire or explosion from dusts.

THE PURPOSES OF THE CODE:

It is well to review the purposes of the code as outlined in the following quotation from the Introduction of the Code.

- a. "The purpose of this Code is the practical safeguarding of persons and property from hazards arising from the use of electricity."
- b. The Code contains provisions considered necessary for safety. Compliance therewith and proper maintenance will result in an installation, essentially free from hazard, but not necessarily efficient, convenient, or adequate for good service or future expansion of electrical uses.
- c. The Code is not intended as a design specification or an instruction manual for untrained persons.

The Code is revised from time to time but not necessarily at regular intervals. Usually the Code is reissued every two or three years. Each new Code carries changes in the rules as compared with the previous issue. New Sections or even new Articles are added from time to time.

Give examples of installations that must be made in dust areas. Show how the fittings must be explosion-proof, dust-ignition proof, or dust tight, depending upon the nature of the hazard.

APPLICATION:

The students will answer the questions on the Assignment Sheet for this lesson.

CHECKING AND FOLLOW-UP:

Check the answers and return the sheets to the students for correction and placing in their workbooks.

NAME _____

LESSON C-10

DATE _____

WORKSHEET

CLASS II INSTALLATIONS

(HAZARDOUS LOCATIONS)

1. Class II locations are those which are hazardous because of the presence of COMBUSTIBLE DUSTS.
2. Explosion-proof equipment is not acceptable in Class II installations unless approved for such locations.
3. Describe the meaning of "dust-ignition-proof" as used in Article 502.
EXCLUDE IGNITABLE AMOUNTS OF DUSTS AND WILL NOT PERMIT ARCS, SPARKS,
OR HEAT GENERATED TO THE OUTSIDE TO IGNITE EXTERIOR ACCUMULATIONS
ON THE ENCLOSURE.
4. Generally the maximum surface temperatures under actual operating conditions permitted under this article for equipment not subject to overloading is 165 °C (329 °F).
5. Generally the maximum surface temperature permitted under this article for a motor is 120 °C (248 °F).
6. List three construction requirements for vaults containing transformers, containing a liquid which will burn, installed in Class II, Division 1 locations:
 - (a) SELF-CLOSING FIRE DOORS ON BOTH SIDES OF WALL
 - (b) VENT OPENINGS ONLY TO THE OUTSIDE
 - (c) OUTSIDE PRESSURE-RELIEF OPENINGS
7. Is it necessary to install a capacitor, not containing a liquid that will burn, in a vault in Class II, Division 1 area? NO, IF APPROVED
FOR CLASS II.
8. No transformer shall be installed in a production area for METALLIC powder.
9. List two conditions under which a dry-type transformer may be installed without a vault in a Class II, Division 1 area:
 - (a) WINDINGS & TERMINALS ENCLOSED AND NOT VENTILATED
 - (b) OPERATE AT 600 VOLTS AND BELOW
10. All Class II, Divisions 1 and 2 shall be protected from HIGH - voltage surges using LIGHTNING protective devices, INTERCONNECTION of all grounds and SURGE protective capacitors.

11. In Class II, Division 1 installations, threaded rigid METAL CONDUIT and Type MI cable shall be installed.
12. Fitting and boxes in Class II, Division 1 areas shall be DUST - IGNITION proof and approved for CLASS II locations.
13. EMT is permitted as a RACEWAY in Class II, Division 2 areas.
14. List two wiring methods where seals may be omitted in Class II, Divisions 1 and 2 areas:
 - (a) HORIZONTAL RUN OF CONDUIT AT LEAST 10 FT. LONG
 - (b) VERTICAL RUN OF CONDUIT AT LEAST 5 FT. LONG
15. Circuit breaker enclosures in Class II, Division 1 areas shall be DUST - IGNITION PROOF.
16. Motors in Class II, Division 1 areas shall be TOTALLY ENCLOSED nonventilated and shall be approved as DUST - IGNITION PROOF for CLASS I locations.
17. Motors in Class II, Division 2 areas TOTALLY ENCLOSED.
18. Ventilating piping for electrical equipment shall be constructed of metal no lighter gauge than No. 24 USS.
19. Lighting fixtures for Class II, Division 1 areas shall be DUST - IGNITION PROOF approved for Class II installation.
20. Maximum pendant length for lighting, fixtures in Class II, Division 1 areas shall be 12 inches.
21. On chain-mounted pendant fixtures, SEALS shall be installed at the entrance of cord with outlet box and fixture.
22. List two conditions which a lighting fixture is acceptable in a Class II, Division 2 area even though it is not approved for a Class II installation:
 - (a) DESIGNED TO MINIMIZE DEPOSIT OF DUST ON LAMPS AND PREVENT SPARKS, BURNING MATERIAL, OR HOT METAL
 - (b) DOES NOT EXCEED MAXIMUM SURFACE TEMPERATURE OF 165°C (329°F) UNDER NORMAL CONDITIONS OF USE
23. Fluorescent lamps conforming to requirements may be installed in Class II, Division 2 areas.

NAME _____

LESSON C-10

DATE _____

WORKSHEET

24. List two requirements for installing receptacles and plugs in Class II, Division 1 areas:
- (a) DUST-IGNITION PROOF
 - (b) CAP AND PLUG CONNECTED TO GROUNDING CONDUCTOR OF CORD
25. What is the difference between the requirements for installing a receptacle in a Class II, Division 2 area, and a Class II, Division 1 area? IN A CLASS II, DIVISION 2 LOCATION THE SUPPLY CONDUCTORS CANNOT BE MADE OR BROKEN WHILE LIVE PARTS ARE EXPOSED.
26. In a class II division I location, is it necessary to always install communication wiring in a metal raceway or use Type MI cables? YES
27. There shall be no exposed LIVE parts in Class II, Divisions 1 and 2 areas.
28. In Class II, Divisions 1 and 2, all exposed non-current carrying metal parts shall be GROUND.
29. Bonding JUMPERS shall be installed for bonding purposes in Class II, Divisions 1 and 2 installations.

CLASS III INSTALLATIONS

(HAZARDOUS LOCATIONS)

DESIRED RESULTS:

To acquaint the apprentice with the safety devices used in hazardous locations, called Class III.

INTRODUCTION:

Class III deals with activities in which fire or explosion may result from combustible fibers.

Electricity is a powerful force. Under control, it safely performs an endless variety of work for us; uncontrolled, it can lead to harm and damage. It is under control when the right kinds of materials are installed in the right way. It becomes uncontrolled when the wrong kinds of materials are used or when the right kinds of materials are wrongly installed.

Uncontrolled electric power can cause fires that can kill people and lead to a multitude of costly results. When these things happen, individuals and companies are the greatest sufferers. Insurance companies also suffer losses, which can result only in higher rates which individuals are called upon to pay. Insurance companies have led the way in setting up of minimum standards of quality in electrical materials as well as uniform methods of installation.

PRESENTING THE LESSON:

In the State of North Carolina, there are many examples of mills which store, process, and weave cloth that have hazardous locations that may cause fibers to burn. Locations in which ignitable fibers are merely stored or handled, other than in the actual process of manufacture, are assessed to Class III, Division 2. This classification applies mostly to warehouses in which manufactured goods, materials in bales, are held for shipment to consumers.

Study Article 503 of the NEC for this assignment. Help the students interpret the rules set up for wiring methods in the areas where combustible fibers are stored or processed.

APPLICATION

Have the students answer questions on the Assignment Sheet for this lesson.

CHECKING AND FOLLOW-UP:

The answers will be checked and the sheets will be returned to the students for placing in the notebooks.

NAME _____

LESSON C-11

DATE _____

WORKSHEET

CLASS III INSTALLATIONS

(Hazardous Locations)

1. Class III locations are hazardous due to the presence of IGNITABLE
DUSTS and FLYINGS.
2. Rigid METAL CONDUIT or type M1 (also MC, CS or "ALS")
cable shall be installed in Class III, Division I areas.
3. Flexible connections shall be made with DUST - TIGHT -
connectors in Class III, Division I and II areas.
4. Open WIRING may be installed in Class III, Division 2 locations,
used solely for storage and containing no machinery.
5. Partially enclosed type or SPLASH - PROOF motors shall
not be installed in Class III locations.
6. Maximum pendant length on a lighting fixture is 12 inches in
a Class III location.
7. Electric - DISCHARGE lighting fixtures with guard may be in-
stalled in Class III locations.
8. In Class III locations, the power supply for cranes shall be
ISOLATED from all other systems and GROUNDED.
9. Recording GROUND DETECTORS shall be installed on crane
systems in Class III locations.
10. Storage battery charging equipment shall be installed in SEPARATE
ROOMS in Class III locations.
11. In Class III installations, all exposed non-current-carrying metal
parts shall be GROUNDED.
12. There shall be no exposed live parts in Class III areas except for
CRANES and HOISTS and RAIL CLEANERS.
13. List two conditions for receptacles and plugs for Class III areas:
 - a. GROUNDED
 - b. MAKE/BREAK NOT COMPLETELY EXPOSED

14. In general, TOTALLY enclosed motors shall be installed in all Class III areas.
15. List two requirements for construction of lighting fixtures in Class III areas:
- a. DUST-TIGHT
 - b. RETAIN EXPLOSION WITHIN FIXTURE
16. Maximum surface temperature of a lighting fixture shall not exceed 165 ° C (329°F) under normal conditions of use.

COMMERCIAL GARAGES, REPAIR, AND STORAGE

DESIRED RESULTS:

To become acquainted with the National Fire Protection Association Standards in certain hazardous locations;

Used for service and repair operations in connection with self-propelled vehicles (automobiles, busses, trucks, tractors, etc.) in which volatile flammable liquids or gases are used for fuel or power.

INTRODUCTION AND PRESENTATION:

The provisions of this article shall apply to occupancies which may be hazardous because of atmospheric concentrations of explosive gases or vapors, or deposits of materials which may be readily ignitable,

The general rules of this Code shall apply to the installation of electrical wiring and equipment in occupancies within the scope of this article except as such rules are modified. Where unusual conditions exist, the Code enforcing authority shall judge with respect to the application of specific rules. The Code enforcing authority shall be familiar with National Fire Protection Association standards applying to occupancies included within the scope of this article.

1. Commercial garages, repair, and storage. This classification shall include locations used for service and repair operations in connection with self-propelled vehicles in which volatile flammable liquids or gases are used for fuel or power.
2. Parking and storage garages used for parking and storage and where no repair work is done and only routine maintenance work requiring no use of electrical equipment, open flame, welding or the use of volatile flammable liquids are not classified as hazardous areas.

Have the students study the articles assigned and give individual help where needed.

APPLICATION:

Have the students complete the answers to the questions on the Assignment Sheet for this lesson.

CHECKING AND FOLLOW-UP:

Check the answers to the questions and return them to the students for correction and placing in their workbooks.

NAME _____

LESSON C-12

DATE _____

WORKSHEET

COMMERCIAL & STORAGE GARAGES

1. A parking garage is: USED FOR PARKING AND STORAGE WHERE NO REPAIR WORK EXCEPT EXCHANGE OF PARTS AND ROUTINE MAINTENANCE REQUIRING NO USE OF ELECTRICAL EQUIPMENT, OPEN FLAME, WELDING OR USE OF VOLATILE LIQUIDS IS EMPLOYED
2. Each floor up to 18 above the floor is considered class I Division II unless mechanical ventilation provides a minimum of 4 air changes per hour.
3. Pits and depressions below floor level shall be considered Class I Division I locations. If 6 air changes per hour are exhausted at the floor level of the pit, it may be classified as a Class I Division II location.
4. Can a wire-guard drop cord with switch and receptacle be used in a commercial garage? NO Answer is found in Article 511-2 (F).
5. Raceways embedded in a masonry wall or buried beneath a floor shall be considered to be WITHIN the hazardous area above the floor.
6. Conduit seal-offs (are-are not) ARE required in commercial garage areas, within the horizontal and VERTICAL boundaries of the defined hazardous areas.
7. List six (6) types of wiring methods which may be used above hazardous areas:
 - a. METALLIC RACEWAYS
 - b. MI CABLE
 - c. TC CABLE
 - d. SNM CABLE
 - e. MC CABLE
 - f. RIGID NON-METALLIC CONDUIT
8. Receptacles in non-hazardous areas shall be of POLARIZING type.
9. Battery CHARGING equipment shall not be located within the hazardous area.
10. Can electric vehicles be charged in a commercial storage garage?
Yes/No YES Give the code section 511-8.

11. Flexible codes shall have:

- a. Approval for EXTRA HARD usage
- b. Adequate AMPACITY for charging current
- c. Connector rating of no less than 50 amperes.
- d. Connectors will DISCONNECT readily at any position.

12. Is a molded composition switched lampholder with a grounded plug-in receptacle permitted in a commercial garage? _____ Give N.E. Code to support your answer. 511-6.

AIRCRAFT HANGARS

(Special Occupancies)

DESIRED RESULTS:

To acquaint the student with the classification that includes locations used for storage and servicing of aircraft.

INTRODUCTION:

Aircraft hangars are assigned similar regulations as commercial garages, but stricter protection. This classification shall include locations used for storage and servicing of aircraft in which gasoline, jet fuels, or other volatile flammable liquids are used.

PRESENTING THE LESSON:

Call attention to the following areas and have the students read each subject in the Code reference.

- a. Hazardous Areas
- b. Wiring and Equipment within Hazardous Areas
- c. Wiring not within Hazardous Areas
- d. Equipment not within Hazardous Areas
- e. Stanchions, Rostrums, and Docks
- f. Approved Seals
- g. Aircraft Electrical Systems
 - (1) De-Energizers
 - (2) Energizers
- h. Aircraft Battery
 - Charging and Control Equipment
- i. Mobile Servicing Equipment
- j. Grounding

APPLICATION:

The students will answer the questions on the Assignment Sheet.

CHECKING AND FOLLOW-UP:

Check the answers to the questions, return the sheets to the students for corrections and placing in their workbooks.

NAME _____

LESSON C-13

DATE _____

WORKSHEET

AIRCRAFT HANGARS

1. The entire hangar floor up to a level 18 inches above the floor is considered to be Class I, Division II area.
2. The area 5'-0" above an aircraft wing is considered a Class I, Division II area.
3. Any area within 5 feet of an aircraft is considered hazardous.
4. Fixed wiring in the non-hazardous area of a hangar shall be installed in CONDUIT, EMT, Type MI cable or Type MC cable.
ALTERNATE ANSWER - TYPE TC, SWM
5. Seals shall be installed on CONDUITS passing from hazardous areas.
6. Aircraft BATTERIES should not be charged while the aircraft is located in the hangar.
7. All metallic raceways and non-current-carrying parts of fixed equipment or portable equipment regardless of voltage shall be GROUNDED.
8. Service equipment not equipped for Class I, Division 2 locations shall not operate within hazardous locations and within 5 feet of aircraft.
9. What type of permanent warning sign shall be attached to mobile aircraft energizers and service equipment?

WARNING

KEEP 5 FT. CLEAR OF
AIRCRAFT ENGINES AND
FUEL TANK AREAS

10. Aircraft energizers should have automatic controls to ISOLATE the ground power unit electrically in case excessive VOLTAGE is generated.
11. Aircraft energizer flexible cords shall include a GROUNDING conductor, and be approved for EXTRA HARD usage.
12. Does portable mobile service equipment operated near aircraft which operates at a low voltage have to be grounded? YES Give N.E.
Code section for your answer. 513-12

GASOLINE DISPENSING AND SERVICE STATIONS

(Special Occupancies)

DESIRED RESULTS:

To acquaint the apprentice with the classification that includes locations used for Gasoline Dispensing and Service Station work.

INTRODUCTION AND PRESENTATION:

Space in the immediate vicinity of a gasoline dispensing island is denoted as Class I, Division 1, to a height of 4 feet above grade. Bulk storage plants for gasoline are subject to comparable restrictions.

This classification shall include locations where gasoline or other volatile flammable liquids are transferred to the fuel tanks of self-propelled vehicles. Dispensing islands are areas extending 18 inches in all directions from the base of the pump. Where an individual pump or dispensing device is not mounted on an elevated island, an area extending 18 inches in all directions from the base of the pump shall be considered to be in dispensing island.

Call attention to the following areas and have the students read the restriction for each subject in the Code reference.

- a. Hazardous Areas
- b. Wiring and Equipment within and not within Hazardous Areas
- c. Circuits Disconnects
- d. Sealing
- e. Grounding

APPLICATION:

Have the students answer the questions provided on the Assignment Sheet for this lesson.

CHECKING AND FOLLOW-UP:

After checking the answers, return the sheets to the students for corrections and placing in their workbooks.

NAME _____

LESSON C-14

DATE _____

WORKSHEET

GASOLINE DISPENSING AND SERVICE STATIONS

1. What locations shall be included in the classifications?
WHERE GASOLINE OR OTHER VOLATILE FLAMMABLE LIQUIDS OR GASES ARE
TRANSFERRED TO FUEL TANKS OF SELF-PROPELLED VEHICLES.
2. List the three areas of a gasoline dispenser which are classified as Class I, Division 1 locations:
 - (a) WITHIN DISPENSER UP TO 4 FT. FROM BASE
 - (b) 18" HORIZONTALLY AND UP TO 4 FT. FROM BASE ON OUTSIDE OF DISPENSER
 - (c) ANY SPACE BELOW DISPENSER CONTAINING ELECTRICAL EQUIPMENT
3. Any area located within 20 feet of the gasoline dispenser area shall be classified Class I, Division II.
4. What classification of hazardous area extends to 18 inches above drive?
CLASS I, DIVISION II
5. What are the classification and limits around the tank fill pipe?
CLASS I, DIVISION II WITHIN 10 FT. RADIUS AND 18" ABOVE GROUND
CLASS I, DIVISION I BELOW GRADE.
6. Electrical wiring and equipment below grade around the dispenser shall be classified as Class I, Division I.
7. List three conditions and classifications for tank vent pipes:
 - (a) SPHERICAL VOLUME WITHIN 3 FT. RADIUS - CLASS I, DIVISION I
 - (b) AREA FROM 3 FT. TO 5 FT. RADIUS - CLASS I, DIVISION II
 - (c) NON-UPWARD DISCHARGE - 5 FT. CYLINDER TO GROUND - CLASS I, DIV. II
8. Circuit breakers shall be capable of disconnecting all SUPPLY conductors including the NEUTRAL simultaneously on circuits to dispensers.
9. Seals shall be installed in all conduits entering or leaving DISPENSING pump or other enclosures located in Class I, Division I or II when connecting conduit originates in a NON - HAZARDOUS location.
10. The first fitting in a dispenser after the conduit emerges from the concrete slab shall be a SEAL-OFF.

11. What electrical equipment must be grounded under this article?

- (a) DISPENSING PUMPS METALLIC PARTS
- (b) METALLIC RACEWAYS
- (c) NON-CURRENT CARRYING PARTS OF ELECTRICAL EQUIPMENT

12. Does all underground wiring have to be in rigid metal conduit?

NO Give Code section for your answer. 514-8

13. What other types of wiring are permitted?

- (a) TYPE MI CABLE
- (b) NON-METALLIC CONDUIT WHEN BURIED AT LEAST 24 INCHES BELOW GRADE AND HAS AN EQUIPMENT GROUNDING CONDUCTOR INSTALLED

BULK-STORAGE PLANTS

(Special Occupancies)

DESIRED RESULTS:

To acquaint the apprentice with the classification that includes locations where gasoline or other volatile flammable liquids are stored in tanks of one carload or more.

INTRODUCTION AND PRESENTATION:

Bulk storage plants for gasoline are subject to comparable restrictions as aircraft hangars. The products stored in these large tanks are usually distributed by tank truck.

Call attention to the following areas and have the students read the rules for each subject in the Code reference:

- a. Hazardous Areas
- b. Wiring and Equipment within and above Hazardous Areas
- c. Underground Wiring
- d. Sealing
- e. Gasoline Dispensing
- f. Grounding

APPLICATION:

Have the students answer the questions provided on the Assignment Sheet for this lesson.

CHECKING AND FOLLOW-UP:

After checking the answers, return the sheets to the students for correction and placing in their workbooks.

NAME _____

LESSON C-15

DATE _____

WORKSHEET

BULK-STORAGE PLANTS

1. List locations included under this Article:
 - (a) ONE CARLOAD CAPACITY OF GAS OR VOLATILE FLAMMABLE LIQUIDS ARE STORED
 - (b) AREA FROM WHICH THEY ARE DISTRIBUTED
2. In ventilated indoor areas containing a gasoline pump, the classification shall be Class I, Division II for 5 feet horizontally and 5 feet vertically above the floor.
3. The immediate area within 25 feet horizontally and 3 ft. vertically above the pump shall be classified as Class I, Division II.
4. List restrictions and classification for an unventilated area containing a gasoline pump.
 - (a) CLASS I, DIVISION I, 5 FT. IN ALL DIRECTIONS
 - (b) CLASS I, DIVISION I, 25 FT HORIZONTALLY - 3 FT. ABOVE GRADE
 - (c) CLASS I, DIVISION II, 3 FT. UPWARD - ABOVE GRADE OR FLOOR
5. List restrictions and classifications for an outdoor pump installation.
 - (a) CLASS I, DIVISION I - 3 FT. FROM PUMP OR FITTING
 - (b) CLASS I, DIVISION II - 5-5 FT. FROM PUMP OR FITTING
 - (c) CLASS I, DIVISION II - 1 1/2 FT. FROM BOTTOM CONNECTION THRU CLOSED DOME - 10 FT. FROM BOTTOM CONNECTION + 18" ABOVE GRADE.
6. Office buildings outside the 25-foot radius of the storage tank have a NON - HAZARDOUS classification.
7. All electrical equipment within the hazardous area shall conform to Article 501.
8. Underground plastic conduit or duct may be installed in a hazardous area if buried 2 feet or more below grade.
9. Where shall seals be installed? NEC SECTIONS: (A) 501-5
(B) 501-5 (A) (4) (C) 501-5 (B) (2)
10. What type of grounding is required under this Article?
 - (a) METALLIC RACEWAYS
 - (b) NON-CURRENT CARRYING ELECTRICAL EQUIPMENT AND ENCLOSURES
11. Buried raceways under defined hazardous areas shall be considered to be WITHIN the hazardous area.

FINISHING PROCESSES

(Hazardous Locations)

DESIRED RESULTS:

1. To acquaint the student with the hazardous areas where volatile flammable solvents or thinners are used.
2. To point out safeguards for finishing processes such as guarding, fire protection, posting warning signs and a good maintenance program.

INTRODUCTION:

For further information regarding safeguards for finishing processes such as guarding, fire protection, posting of warning signs, and maintenance, see NFPA Standard for Spray Finishing Using Flammable and Combustible Materials No. 33-1973 and NFPA Standard for Dip Tanks Containing Flammable or Combustible Liquids No. 34-1974. For additional information regarding ventilation, see NFPA Standard for Blower and Exhaust Systems No. 91-1973.

PRESENTING THE LESSON:

Call attention to the important items listed in Article 516 and help the students interpret these items that are directly related to wiring methods. The items of this Article are listed below under their general headings.

- a. Definition
- b. Hazardous Areas
- c. Wiring and Equipment in Hazardous Areas
- d. Fixed Electrostatic Equipment
- e. Electrostatic Hand-Spraying Equipment
- f. Powder Coating
- g. Wiring and Equipment above Hazardous Areas
- h. Grounding

NOTE: It is important for the apprentice to know how to handle installations in plants that have these finishing processes because of the increasing number of installations in this part of the country.

APPLICATION:

The students should complete the Assignment Sheet or Worksheet for this lesson.

CHECKING AND FOLLOW-UP:

Check the answers and review the errors for correction and filing in their notebooks.

NAME _____

LESSON C-16

DATE _____

WORKSHEET

FINISHING PROCESSES

1. What are the three main methods of applying finishes?
 - a. SPRAYING
 - b. DIPPING
 - c. BRUSHING
2. What are the hazardous substances involved in applying finishes?
 - a. PAINT
 - b. LACQUER
 - c. SOLVENTS
 - d. THINNER
 - e. IGNITABLE DEPOSITS
 - f. RESIDUES
3. The hazardous classification of Class I Division I covers areas within 20 feet horizontally and 10 ft. vertically of paint spray booths.
4. The hazardous classification of Class I Division I covers areas within 20 feet horizontally of dip tank and their drain boards.
5. The hazardous classification of Class I Division II covers the area beyond the limits of Class I Division I around paint spray booths and dip tanks.
6. What two requirements must be met for an area utilizing drying, curing or fusion apparatus to be classified as non-hazardous?
 - a. POSITIVE MECHANICAL VENTILATION
 - b. INTERLOCKS TO STOP ELECTRICAL EQUIPMENT IF VENTILATION EQUIPMENT IS INOPERATIVE.
7. Is a lighting fixture approved for Class I Division 1 locations acceptable within the 20 ft. area of a spray booth? Yes / No NO
Give the N. E. Code section for your answer 516-3 (c).
8. Explain in your own words the meaning of Section 516-3 (c) of the N. E. Code. THE DRY PAINT RESIDUE SETTLING ON THE FIXTURE HOUSING COULD GET HOT ENOUGH TO IGNITE AND BURN.

9. Give the five conditions which must be met to put a lighting fixture behind a panel of glass or other translucent material.
- a. FIXED LIGHTING UNITS ARE USED
 - b. THE PANEL ISOLATES THE FIXTURE FROM THE HAZARDOUS AREA
 - c. THE FIXTURE IS APPROVED FOR ITS LOCATION
 - d. THE PANEL MATERIAL IS PROTECTED AGAINST BREAKAGE
 - e. RESIDUE ON THE PANEL WILL NOT BECOME IGNITED BY HEAT FROM THE FIXTURE.
10. Electrostatic spraying equipment generally consists of the following components:
- a. TRANSFORMERS
 - b. POWER PACKS
 - c. CONTROL APPARATUS
 - d. HIGH VOLTAGE GRIDS
 - e. ELECTRODES
 - f. ELECTROSTATIC ATOMIZING HEADS
 - g. CONVEYER SYSTEM
11. What four conditions will shut down an electrostatic spraying operation to prevent danger to the operator or a fire from starting?
- a. FAILURE OF VENTILATING SYSTEM
 - b. CONVEYER STOPPING IN HIGH-VOLTAGE FIELD
 - c. A GROUND IN THE HIGH-VOLTAGE SYSTEM
 - d. UNSAFE CLEARANCE BETWEEN ELECTRODES AND OBJECT BEING PAINTED
12. What determines the hazardous rating of a powder coating operation?
CHEMICAL COMPOSITION OF THE MATERIAL, PARTICLE SIZE, SHAPE,
AND DISTRIBUTION.

13. List the two methods of applying coating powders.

a. ELECTROSTATIC FLUIDIZING BED

b. ELECTROSTATIC POWDER SPRAY GUN

HEALTH CARE FACILITIES

(Special Occupancies)

DESIRED RESULTS:

1. To acquaint the apprentice with the Code that includes general area wiring systems and essential electrical systems in locations where combustible anesthetics are used in Health Care Facilities.
2. To study the definitions of terms used in Health Care Facilities along with an understanding of the various electrical installations listed in the Code.

INTRODUCTION:

The 1978 Code devotes more space to these facilities than is generally given to a single subject. Also, many articles and interpretations have been published concerning this article in the Code.

The attached Information Sheets from recognized authorities have been prepared for the convenience of both instructor and students in helping to comprehend this task.

Special attention should be given to diagrams 517-42(1) & (2), 517-60(1) & (2) of 1978 N.E. Code.

You should have a copy of Crouse-Hinds, Code Digest, Articles 500-503 and 510-517 of the 1978 NEC, for ready reference in discussing this subject with your class.

NOTE: Several members of the revision committee felt that much of this material should be left out of the lesson materials. They felt that the information concerning Health Care Facilities is a problem for Design Engineers and Manufacturing.

The chairman of the committee made the following statement concerning the subject. "I agree with the members of the committee, however, our electricians are charged with the correct and proper installation of the wiring systems. All the electrical health facilities are connected to this wiring. I want the apprentices to have a little knowledge of 'why' the job is done according to the N. E. Code. After all, this is the concern of related training."

PRESENTING THE LESSON:

Combustible anesthetics are gases or vapors which may form flammable or explosive mixtures with air, oxygen or nitrous oxide.

Anesthetizing locations are areas in hospitals in which combustible anesthetics are or may be administered to patients. Such locations will include any area that may be used for the above purpose as operating rooms, delivery rooms, anesthesia rooms, any corridors or utility rooms. Recovery rooms are not classed as anesthetizing locations unless used for the purpose.

Call attention to the following areas and have the students read the Code references for each subject:

- A. General scope and definitions.
- B. General area wiring systems
- C. Essential electrical systems
- D. Patient care areas
- E. Inhalation anesthetizing locations
- F. Communications, signaling systems, & data systems

In a Health Care Facility, the emergency system is divided into three main divisions:

- 1. Life safety branch
- 2. Critical branch
- 3. Life support branch

Try to present the wiring problems of the electrician working in a Health Facility in organized manner. Stress the importance that each area is installed separately and each area has its particular wiring methods and problems.

Stress the wiring of Hazardous Areas, the need and the selection of types and compounds used in sealing fittings. Select other important areas to stress in the lesson.

It may be that you will need several sessions of class time to discuss this important section of the Code.

APPLICATION:

The students will answer the questions on the Assignment Sheet for this lesson.

CHECKING AND FOLLOW-UP:

After checking the answers, return the sheets to the students for corrections and placing in their workbooks.

NAME _____

LESSON C-17

DATE _____

WORKSHEET

HEALTH CARE FACILITIES

1. Article 517 in the N.E. Code contains 10 parts. List them and what they cover.
 - a. GENERAL-SCOPE AND DEFINITIONS
 - b. WIRING SYSTEMS-GENERAL
 - c. CLINICS, MEDICAL & DENTAL OFFICES & OUT-PATIENT FACILITIES
 - d. NURSING HOMES & RESIDENTIAL CUSTODIAL CARE FACILITIES
 - e. HOSPITALS
 - f. PATIENT CARE AREAS
 - g. INHALATION ANESTHETIZING LOCATIONS
 - h. COMMUNICATIONS, SIGNAL SYSTEMS, DATA SYSTEMS, FIRE PROTECTIVE SIGNALING SYSTEMS, AND LOW VOLTAGE SYSTEMS.
 - i. THERAPEUTIC HIGH-FREQUENCY EQUIPMENT
 - j. X-RAY EQUIPMENT
2. In a health care facility, what are the two main divisions of the emergency system?
 - a. LIFE SAFETY BRANCH
 - b. CRITICAL BRANCH
3. What are the emergency system branches of a Nursing Home or Residential Custodial Care Facility?
 - a. LIFE SAFETY BRANCH
 - b. CRITICAL BRANCH
4. Feeders and branches of the above emergency systems shall be _____ from all other wiring systems.
5. All branches of the emergency system shall be restored to operation within 10 seconds of a power interruption.
6. In patient care areas, what are the minimum requirements for an equipment grounding conductor?
 - a. Size #10 AWG
 - b. Material COPPER
 - c. Construction STRANDED WIRE
 - d. Installation RUN WITH CIRCUIT CONDUCTORS
 - e. Bonding TO PATIENT GROUNDING POINT

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7. What hazardous classification is given to areas used for storing flammable anesthetics or volatile flammable disinfecting agents?

CLASS I, DIVISION I

8. The entire anesthetics area up to 5 feet above the floor is classified as Class I, Division I location.
9. Raceways in masonry walls are considered to be in a HAZARDOUS area.
10. Conduits in block walls in an anesthetics area are in a HAZARDOUS area.
11. Boxes in a masonry wall in an anesthetics area are in a HAZARDOUS area.
12. MI cables may be installed in HAZARDOUS areas.
13. List three types of wiring permitted in a hazardous area.
- | | | |
|--------------------------|---------------------|--------------------|
| a. <u>METAL RACEWAYS</u> | c. <u>ALS CABLE</u> | e. <u>MC CABLE</u> |
| b. <u>MI CABLE</u> | ALTERNATE ADDITIONS | |
| | d. <u>CS CABLE</u> | |
14. Seals shall be installed in CONDUITS passing from anesthetics area.
15. In anesthetics area, each circuit shall have a switch to disconnect each CIRCUIT conductor.
16. Each circuit shall be supplied from an UNGROUNDED distribution system.
17. List three methods used for circuit isolation:
- | | |
|----------------------------|---------------------------------------|
| a. <u>TRANSFORMERS</u> | c. <u>SUITABLY ISOLATED BATTERIES</u> |
| b. <u>MOTOR GENERATORS</u> | |
18. Secondary voltage of an isolation transformer shall not exceed 300 volts.
19. Primary voltage to isolation transformer shall not exceed 300 volts.

20. Overcurrent PROTECTION shall be installed in secondary neutral of isolation transformer.
21. Current through the ground indicator shall not exceed 2 MILLI -amperes.
22. Grounded branch circuits and ungrounded branch circuits shall be installed in SEPARATE raceways in anesthetic area.
23. Fixed lighting fixtures in anesthetic area shall be mounted at least 8 feet above floor.
24. Switches for grounded circuits shall be located OUTSIDE of anesthetic area.
25. Electrical apparatus used in the hazardous area shall operate at a maximum of 8 volts.
26. Low-voltage supply from a common source for electrical apparatus in hazardous area shall be located in NON-HAZARDOUS locations.
27. Motors used in hazardous area shall be approved for Class I locations.
28. Overcurrent devices for low voltage equipment shall be installed in NON-HAZARDOUS areas.
29. General care areas shall have a minimum of 4 single or 2 duplex receptacles for each patient bed location.
30. Critical care areas shall have a minimum of 6 single or 3 duplex receptacles for each patient bed location.

FUNDAMENTALS OF MOTOR CONTROL

DESIRED RESULTS:

To study the meaning of motor control and the basic differences in manual, semi-automatic, and automatic controls.

INTRODUCTION:

Much of the inside wireman's work is concerned with motors and controllers. It is essential that he acquire a general knowledge of motor types, controls, and other characteristics.

With the advent of mass production, down came the line shaft and the electric motors were installed on individual machines. This change allowed more frequent and more rapid starts, stops and reversals of the machine. Once the drive motor was put on the machine, with the sole function of operating one piece of equipment, it was possible to introduce some automatic operations.

Now, in our industrial plants, the operator sets up the original process and the operations are carried out automatically. These automatic operations are dependent upon motor and machine control. Thus, the modern machine consists of three divisions: 1. The machine, 2. The motor, and 3. The controls.

PRESENTING THE LESSON:

A. Discussion:

1. What is the meaning of motor control?
2. What is an electric controller?
3. Discuss the basic differences in manual, semi-automatic, and automatic controls.

B. Demonstration:

1. Show the construction and demonstrate how several controllers operate.
2. Visit the machine shop and observe the work of motor controls on several machines.

C. Review the Attached Information Sheets:

1. Motor control trouble - remedy table
2. Water soaked motor control - general recommendations

APPLICATION:

Have the student complete the Assignment Sheets for this lesson.

CHECKING AND FOLLOW-UP:

Check the answers and return the papers for correction and placing in their notebooks.

Motor Control Trouble — Remedy Table

The following table lists trouble encountered with motor control, their causes and remedies. This table is of a general nature and covers only the main causes of trouble.

Misapplication of a device can be a cause of serious trouble, however rather than list this cause repeatedly it should be noted here that **misapplication**

is a major cause of motor control trouble and should always be questioned when a device is not functioning properly.

Actual physical damage or broken parts can usually be found quickly and replaced. Damage due to water or flood conditions require special treatment. See page 3 for recommendations for renovating water soaked motor control.

TROUBLE	CAUSE	REMEDY
Magnetic Contactors and Starters		
CONTACTS		
Contact Chatter	1. Broken shading coil. 2. Poor contact in control circuit. 3. Low voltage.	1. Replace. 2. Improve contact or use holding circuit interlock (3 wire control). 3. Correct voltage condition. Check momentary voltage dip during starting.
Welding or Freezing	1. Abnormal inrush of current. 2. Rapid jogging. 3. Insufficient tip pressure. 4. Low voltage preventing magnet from sealing. 5. Foreign matter preventing contacts from closing. 6. Short circuit.	1. Use larger contactor or check for grounds, shorts or excessive motor load current. 2. Install larger device rated for jogging service or caution operator. 3. Replace contact springs; check contact carrier for deformation or damage. 4. Correct voltage condition. Check momentary voltage dip during starting. 5. Clean contacts with carbon tetrachloride, contactors, starters, and control accessories used with very small current or low voltage, should be cleaned with carbon tetrachloride and then with acetone to remove the carbon tetrachloride residue. 6. Remove short fault and check to be sure fuse or breaker size is correct.
Short Tip Life or Overheating of Tips	1. Filing or dressing. 2. Interrupting excessively high currents. 3. Excessive jogging. 4. Weak tip pressure. 5. Dirt or foreign matter on contact surface. 6. Short circuits. 7. Loose connection. 8. Sustained overload.	1. Do not file silver tips. Rough spots or discoloration will not harm tips or impair their efficiency. 2. Install larger device or check for grounds, shorts or excessive motor currents. 3. Install larger device rated for jogging or caution operator. 4. Replace contact springs; check contact carrier for deformation or damage. 5. Clean contacts with carbon tetrachloride. 6. Remove short fault and check to be sure fuse or breaker size is correct. 7. Clean and tighten. 8. Install larger device or check for excessive motor load current.
COILS		
Open Circuit	1. Mechanical damage.	1. Handle and store coils carefully.
Roasted Coil	1. Over voltage or high ambient temperature. 2. Incorrect coil. 3. Shorted turns caused by mechanical damage or corrosion. 4. Under voltage, failure of magnet to seal in. 5. Dirt or rust on pole faces increasing air gap.	1. Check application and circuit. 2. Check rating and if incorrect, replace with proper coil. 3. Replace coil. 4. Correct system voltage. 5. Clean pole faces.

TROUBLE	CAUSE	REMEDY
Magnetic Contactors and Starters		
OVERLOAD RELAYS		
Tripping	1. Sustained overload. 2. Loose connection on load wires. 3. Incorrect heater.	1. Check for grounds, shorts or excessive motor currents. 2. Clean and tighten. 3. Relay should be replaced with correct size heater unit.
MAGNETIC & MECHANICAL PARTS		
Noisy Magnet	1. Broken shading coil. 2. Magnet faces not mating. 3. Dirt or rust on magnet faces. 4. Low voltage.	1. Replace shading coil. 2. Replace magnet assembly or realign. 3. Clean and realign. 4. Check system voltage and voltage dips during starting.
Failure to Pick-up and Seal	1. Low voltage. 2. Coil open or shorted. 3. Wrong coil. 4. Mechanical obstruction.	1. Check system voltage and voltage dips during starting. 2. Replace. 3. Check coil number. 4. With power off, check for free movement of contact and armature assembly.
Failure to Drop-Out	1. Gummy substance on pole faces. 2. Voltage not removed. 3. Worn or rusted parts causing binding. 4. Residual magnetism due to lack of air gap in magnet path.	1. Clean with carbon tetrachloride. 2. Check coil circuit. 3. Replace parts. 4. Replace worn magnet parts.
PNEUMATIC TIMERS		
Erratic Timing	1. Foreign matter in valve.	1. Replace timing head complete or return timer to factory for repair and adjustment.
Contacts Do Not Operate	1. Maladjustment of actuating screw. 2. Worn or broken parts in snap switch.	1. Adjust as per instruction in service bulletin. 2. Replace snap switch.
LIMIT SWITCHES		
Broken Parts	1. Overtravel of actuator.	1. Use resilient actuator or operate within tolerances of the device.
MANUAL STARTERS		
Failure to Reset	1. Latching mechanism worn or broken.	1. Replace part.
COMPENSATORS (MANUAL)		
Welding of Contacts on Starting Side	1. Inching, jogging and operating handle slowly.	1. Excessive inching and jogging not recommended (caution operator) move handle swiftly and surely to start position.
Welding of Contacts Running Side	1. Moving handle slowly to run position. 2. Lack of sufficient spring pressure.	1. Move handle swiftly and surely to run position as motor approaches full speed. 2. Replace contacts and contact springs.
Damaged or Burned Transformer	1. Repeated inching and jogging. 2. Holding handle in start position for long periods.	1. Excessive inching and jogging not recommended (caution operator). 2. Hold handle in start position only until motor approaches full speed.

Water-Soaked Motor Control

GENERAL RECOMMENDATIONS

1. CLEANING — All equipment should be hosed down and scrubbed with a stiff brush. Water pressure should be limited to 25 pounds per square inch maximum on insulating parts. Water temperature should not exceed 90 degrees C., 194 degrees F. maximum. Carbon tetrachloride or any approved solvent should be used for a final cleaning of insulating surfaces, contact tips and magnet pole faces. Contact tips should also be cleaned with acetone to remove the film left by carbon tetrachloride. Steam cleaning should not be used except on cabinets and enclosures from which the interiors have been removed.

2. DRYING — Drying in the sun or in a warm, dry room will take about 2 to 4 days. If heat is used for drying, it should be limited to about 212 degrees F., preferably starting at about 150 degrees or lower and gradually building up to 212 degrees F. Plaster drying equipment, electric heaters, or baking ovens may be used. Approximately 24 hours drying by this method should generally be sufficient. For equipment operating at voltages above 250, greater cau-

tion in drying and cleaning should be taken, because of the greater susceptibility to insulation breakdown.

3. LUBRICATION — All mechanical joints, sliders, bearings, and moving parts should be cleaned and lubricated with any good lubricating oil. Exception: NO OIL SHOULD BE APPLIED TO CONTACT SURFACES OR MAGNET POLE FACES.

4. FINAL CHECK — Test insulation resistance with megger or ohmmeter. A 500 volt or 1000 volt megger is recommended; higher voltages are not suitable for testing controls rated at 600 volts. One megohm is recommended as minimum resistance but equipment should operate satisfactorily with less. In operation, normal drying will cause this resistance value to increase. Restore power to one device at a time, watching for evidence of leakage, spitting, or smoking. For all equipment passing up to this point, load may then be restored, watching for spitting or smoking at contacts. Check to be sure that no open circuit conditions exist.

★ ★ ★

SPECIFIC RECOMMENDATIONS

1. COILS AND TRANSFORMERS — Wash with clean hot water and dry by any of methods listed above, or by applying a low voltage (about 10% of rated voltage) to the coil for 2 or 3 hours. Magnet armature should be in open position or coil should be removed from magnet. For drying D. C. coils by this method, a resistor in parallel with the coil is recommended to provide a discharge path for the kick voltage induced when the circuit is opened. Special care should be taken to dry out D. C. coils, since in operation, the inductive voltage may be several times normal voltage. Check with the megger for insulation resistance (one megohm).

2. MAGNETS — Wash, clean, and dry with cloth or air hose. Lubricate bearings, pins, etc. Clean magnet pole faces with carbon tetrachloride to remove oil film and surface dirt which might cause the armature to stick.

3. CONTACT SURFACES — Clean tips with carbon tetrachloride, then with acetone to remove the carbon tetrachloride film. Filing the tips is not recommended, but may be used if the surface is very difficult to clean. Do not use sandpaper or emery-cloth which would deposit grit on the tips. Small contacts can be "filed" by rubbing Kraft paper over the surface. Particular care should be taken with small contacts such as electrical interlocks, overload relays, and push buttons.

4. INSULATING PARTS — All surfaces of contact blocks, arc chamber covers, yoke bars, overload relay blocks, etc. should be cleaned with carbon tetrachloride, particularly between poles, and dried carefully. Surface drying is generally sufficient for glazed porcelain, melamine, and non-absorbent plastics. Unglazed porcelain, bakelite, and Ros-

tone absorb water and should be baked to dry thoroughly. (Rosstone is the cold molded material used for contact blocks on Size 1, 2, and 3 starters.) Check with megger from pole to pole and from each pole to ground, for one megohm minimum insulation resistance.

5. THERMAL OVERLOAD RELAYS — Melting alloy type relays should be partially disassembled to permit cleaning contacts and moving parts. Lubricate to be sure parts can move freely. Clean heater surfaces to permit normal heat radiation. Bimetallic type overloads should not be taken apart, because of their intricate assembly. For emergency service, they can be used if they check satisfactorily, mechanically and electrically. To check mechanically, remove heater unit and press downward on lower end of bimetal strip with a screwdriver; this should trip the relay and open control circuit contacts. Ultimately, bimetal overload relays should be replaced.

6. SNAP SWITCHES — (Class 9007, Type A0) snap switches should generally be replaced as soon as possible. For temporary use, shake out any water trapped inside, blow out with an air hose, and bake to dry. Check circuit continuity. Dirt inside the case may prevent contacts from closing properly and cause excessive wear on the toggle mechanism. It is generally impractical to attempt opening the case to clean it out.

7. PNEUMATIC TIMERS — Timer heads should not be taken apart. It is recommended that the timer be replaced or returned to the factory for repair. For temporary use, dry timer thoroughly and treat coil, magnet, and snap switch as recommended. Check timing operation. Timer should be suitable for limited use, but will probably not be very accurate, due to dirt in the valves.

NAME _____

LESSON C-18

DATE _____

WORKSHEET

FUNDAMENTALS OF MOTOR CONTROL

A. Match Column B with Column A:

Column A

Column B

- | | |
|--|----------------------|
| <u>F</u> 1. A requirement of service at constant load for an unlimited period. | a. Automatic |
| <u>C</u> 2. Basic functions are performed by hand. | b. Motor control |
| <u>F</u> 3. These items are used on large horsepower motors. | c. Manual controller |
| <u>D</u> 4. The type of control that is used when we have a magnetic starter on a push button "Stop-Start" switch controlling motor. | d. Semi-automatic |
| <u>A</u> 5. Controls eliminates the necessity of a manual control. | e. Continuous duty |
| <u>B</u> 6. Means the governing or regulating the functions of a motor or machine. | f. Compensators |
| <u>H</u> 7. What is the most popular manual controller. | g. Drum switch |
| | h. Full-voltage |

B. Answer the following:

1. What is the purpose of a master switch?

IT SERVES TO GOVERN THE OPERATION OF CONTACTORS AND AUXILIARY DEVICES OF AN ELECTRIC CONTROLLER.

2. What is the purpose of overload protection in a motor circuit?

INTERRUPTS THE CIRCUIT AT EXCESSIVE CURRENTS BUT NOT SHORT CIRCUIT CURRENTS.

3. Why are relays used?

LET ONE ELECTRICAL CIRCUIT CAUSE THE OPERATION OF OTHER DEVICES IN THE SAME CIRCUIT OR OTHER ELECTRICAL CIRCUITS.

4. How does a phase failure device operate?

IT FUNCTIONS ON A REDUCTION OR FAILURE OF VOLTAGE, TO CAUSE THE INTERRUPTION OF POWER IN A MOTOR CIRCUIT.

CONTROL OF MOTOR STARTING

DESIRED RESULTS:

To acquaint the student with the basic principles and general types of automatic motor controls in a simplified manner.

INTRODUCTION:

The subject of motor controllers is of great importance to the industrial electrician. He is often called upon to connect, disconnect, or troubleshoot them. It is necessary that he have a sound knowledge of the principles upon which they operate.

The most common of the controllers is the magnetic switch or across-the-line starter. This starter, combined with pilot devices, can give full protection to the motor and be fully automatic in operation. The student should make sure he understands the purpose of each component. Circuits containing plugging relays should be analyzed and the essential ones memorized. It is not advisable to try memorizing the complicated circuits of reversing or multi-speed motors. However, the material relating to these components should be read carefully.

PRESENTING THE LESSON:

A. Discuss the following types of motor starting with the use of diagrams:

1. Full-voltage starting
2. Reduced-voltage starting
3. Starting Squirrel-cage motors
4. Starting Wound-rotor motors
5. Starting Synchronous motors

B. Discuss the selection of starting controllers:

1. Name the two types of starting control.
2. How many types of protection are there for motors?
3. Do the running conditions of the motor affect the type of control to be used on a motor?
4. What is the difference between an automatic and a semi-automatic controller?
5. Summarize the factors needed to be considered when selecting starting controllers.

C. Problem for illustration:

It is desired that four motors start in the sequence 1, 2, 3, 4, and the start button being depressed only once to establish the sequence of operations. A second requirement is that if one motor stops because of operation of its overload device, or for other reasons, the others will continue to operate. Standard magnetic switches are to be used. Draw the diagram of the circuit on the chalkboard.

APPLICATION:

The students will complete the Assignment Sheets for this lesson.

CHECKING AND FOLLOW-UP:

Check the answers and return the sheets for correction and placing in notebooks.

NAME _____

LESSON C-19

DATE _____

WORKSHEET

CONTROL OF MOTOR STARTING

1. List two "methods of stopping" a motor.
 - a. MANUALLY
 - b. AUTOMATICALLY
2. What type of relay is connected across the line during starting of a reduced-voltage starter to prevent damaging the motor windings or auto transformer? THERMAL RELAY
3. How is phase-failure protection provided? BY USING THREE OVERLOAD RELAY UNITS
4. When does single phase occur in a three-phase motor? WHEN YOU HAVE A CURRENT INTERRUPTION ON ONE PHASE
5. What type pilot devices provide an under-voltage protection? MOMENTARY CONTACT
6. List four general types of speed control.
 - a. CONSTANT SPEED
 - b. VARIABLE SPEED
 - c. MULTI-SPEED
 - d. PREDETERMINED SPEED

7. Match Column B with Column A:

Column A

Column B

- | | | |
|---------------|--|------------------------|
| <u>3</u> | a. What is provided by connecting a heater element in series with the motor leads? | 1. Manual control |
| <u>1</u> | b. What is sensitive to operators reaction only? | 2. Overload relay |
| 2 OR <u>3</u> | c. It does not provide short-circuit protection. | 3. Overload protection |

8. List three means of short-circuit protection.
- a. FUSE
 - b. CIRCUIT BREAKER
 - c. MOTOR SHORT-CIRCUIT PROTECTOR
9. List the two elements of a dual-element fuse. Give the purpose of each.
- a. FUSE LINE - PROVIDES SHORT-CIRCUIT PROTECTION
 - b. THERMAL ELEMENT - PROVIDES OVER-LOAD PROTECTION
10. Interlock in a starter may be accomplished by ELECTRICAL or MECHANICAL connection.
11. Why use reduced voltage starting? BECAUSE STARTING A LARGE MOTOR MAY CAUSE A LARGE SURGE.
12. What is the most popular starter used? ACROSS THE LINE
MAGNETIC

CONTROL COMPONENTS

DESIRED RESULTS:

To give the student an insight into the many variations in devices used to control the functions of motors.

INTRODUCTION:

The selection of control components is carefully made after it has been decided what functions of control are needed for a machine. It should be remembered that a motor can perform only as well as the components in its control circuit. The fact that a certain component is a high quality product does not necessarily mean that it will perform well in a particular circuit. The component must be selected to fit the motor to be controlled and the function to be performed.

PRESENTING THE LESSON:

Discussion Questions:

1. What functions of control are intended to be performed by switches and breakers?
2. Compare a contactor and an across-the-line motor starter.
3. What is meant by a relay? What is required to operate a voltage relay?
4. What is meant by the terms pull-in current, drop-out current, and differential used in connection with current relays.
5. Name two uses for a frequency relay. What are the two basic methods of delaying the closing or opening of the time-delay relays.
6. What is the chief advantage to using an automatic motor starter instead of a manual motor starter? What is meant by clapper-type and solenoid type contact arrangements?
7. Name the three basic magnetic shapes used on modern motor starters.
8. What is the basic difference between a motor starter and a motor controller?
9. What is the common name for a manual reduced-voltage starter? Name three basic methods of obtaining reduced-voltage starting.
10. What is meant by the following:
 - a. Definite time control
 - b. Current-limit control
 - c. Sequence speed control
 - d. Selective speed control
 - e. Automatic speed control
 - f. Reversing starter

APPLICATION:

The students should complete the Assignment Sheets.

CHECKING AND FOLLOW-UP:

Check the answers with the Instructor's Answers. Help those that have trouble finding the correct answers.

NAME _____

LESSON C-20

DATE _____

WORKSHEET

CONTROL COMPONENTS

1. List the six main components of an automatic synchronous motor starter:
 - a. AUTOMATIC REDUCED VOLTAGE STARTER
 - b. FIELD APPLICATION RELAY
 - c. FIELD DISCHARGE RESISTOR
 - d. OVERLOAD PROTECTION
 - e. UNDER VOLTAGE PROTECTION
 - f. CONTACTOR
2. The most common SYNCHRONOUS motor starts like a squirrel-cage motor.
3. The most critical component in a synchronous motor starter is the FIELD - APPLICATION relay.
4. List seven main components of a semi-automatic synchronous motor starter:
 - a. MANUAL COMPENSATOR
 - b. FIELD APPLICATION RELAY
 - c. FIELD RHEOSTAT
 - d. FIELD DISCHARGE RESISTOR
 - e. CONTACTOR
 - f. OVERLOAD PROTECTION
 - g. UNDER VOLTAGE PROTECTION
5. The most common secondary control component for wound-rotor motor starters is the DRUM CONTROLLER.
6. List the five main components of a wound-rotor motor starter:
 - a. FULL VOLTAGE STARTER
 - b. OVERLOAD PROTECTION
 - c. UNDER VOLTAGE PROTECTION
 - d. SECONDARY CONTROLLER
 - e. DRUM CONTROLLER
7. Liquid RHEOSTAT type secondary controller provides the smoothest speed regulation for a wound-rotor motor.
8. List two methods of manually reversing three-phase squirrel-cage motors:
 - a. DRUM CONTROLLER
 - b. SWITCH BETWEEN STARTER AND MOTOR

9. List two methods of automatically reversing single-phase fractional horsepower motors:
a. RELAYS b. STARTERS
10. In lieu of a reversing starter, 2 across-the-line starters, properly connected, may be used.
11. Starters or SWITCHES are a common component to all motors for disconnecting the motor.
12. An isolating switch is rated in VOLTAGE and AMPERES.
13. A switch that is horsepower rated is the MOTOR - CIRCUIT DISCONNECT and will interrupt motor current under normal OVERLOADS.
14. When the above switch is used for motor-circuit protection, it must be FUSED.
15. A circuit breaker may perform start and stop functions, and OVERLOAD and SHORT CIRCUIT protection.
16. A circuit breaker may be used as a motor-circuit SWITCH.
17. Contactors do not provide RUNNING PROTECTION.
18. List two general types of contactors:
a. CLAPPER TYPE
b. SOLENOID TYPE
19. Contactor is a MAGNETICALLY CLOSED switch.
20. A relay is a MECHANICAL amplifier.
21. A relay COIL require a low current for functioning and may be used to CONTROL circuits of large currents.
22. A VOLTAGE relay is the most common type.
23. List five types of relays:
a. VOLTAGE d. TIME
b. CURRENT e. OVERLOAD
c. FREQUENCY

24. Components which use signal relays are called PILOT DEVICES.
25. Current relay operates on RESPONSE to current changes.
26. Relays which are used on very low current circuits are called CURRENT - RELAYS.
27. List two types of current relays:
- a. SPRING TENSION b. THERMAL TYPE
28. An overload relay provides overload and PHASE - FAILURE protection in motor circuits.
29. List three types of overload relays:
- a. RATCHET
- b. BIMETALLIC
- c. MAGNETIC
30. Thermal relays trip on heat and are called COMPENSATED OVERLOAD relays.
31. Magnetic overload relays sense motor CURRENTS.
32. Overload relays must be reset after each TRIPPING.
33. What is the difference between a "motor-starter" and "motor controller"? STARTER: CONTAINS MEANS OF CONNECTING MOTOR TO LINE PLUS PROTECTION. CONTROLLER: CONTAINS STARTER PLUS SENSING DEVICES RELAYS, ETC.
34. NEMA Type I enclosures are for general purpose use.
35. NEMA Type 3 enclosures are WEATHER - TIGHT.
36. A MANUAL motor starter depends upon the operator to close the line contacts by pushing a button which is physically linked to the contacts.
37. A MAGNETIC motor starter closes the line contacts magnetically.
38. The manual starter lacks FLEXIBILITY of control.

39. List three classes of manual starters:
- a. THERMAL
 - b. ACROSS THE LINE
 - c. REDUCED VOLTAGE
40. The MAGNETIC starter provides unlimited flexibility of control.
41. List the two classifications of the magnetic starter:
- a. CLAPPER TYPE
 - b. SOLENOID TYPE
42. Full-VOLTAGE starters are the most widely used.
43. Reduced-voltage starters are used to limit the INRUSH OF CURRENT during the starting cycle.
44. Compensators are MANUAL reduced-voltage starters.
45. Closed-TRANSITION start occurs when there is no interruption of current from reduced-voltage to full-voltage operation.
46. Auto-TRANSFORMER reduced voltage starter is an open-transition starter.
47. Magnetic starters for multispeed motors must have a CONTACTOR for each speed.
48. List the three types of multispeed control:
- a. SELECTIVE
 - b. SEQUENCE
 - c. AUTOMATIC
49. The combination STARTER includes a switch or circuit breaker and a motor starter in the same enclosure.

NAME _____

LESSON C-21

DATE _____

WORKSHEET

PILOT DEVICES

1. Motor-control circuit components may be classified as PRIMARY
CONTROL devices or PILOT CONTROL devices.
2. Pilot control devices CONTROL or MODULATE primary control devices.
3. A magnetic starter is a PRIMARY CONTROL device.
4. List four types of pilot devices:
 - a. PUSH BUTTON
 - c. PRESSURE SWITCH
 - b. FLOAT SWITCH
 - d. THERMOSTAT
5. List two primary control devices for a motor:
 - a. STARTER
 - b. CONTROLLER
6. Overload RELAYS are pilot devices.
7. Pilot DEVICES are sensing devices.
8. Float SWITCHES operates on the level of liquids.
9. List two types of float switches:
 - a. PIVOT ARM
 - b. DRUM TYPE
10. List three classes of pressure switches:
 - a. BELLOWS
 - b. DIAPHRAM
 - c. TUBE
11. List two classifications of limit switches:
 - a. DRUM TYPE CHAIN
 - b. DRUM TYPE DIRECT
12. Flow SWITCHES sense the flow of liquid, air or gas through a pipe.

13. List three types of thermostats:

- a. BELLOWS
- b. BIMETALLIC
- c. MODULATING

14. Push - BUTTON STATION is most commonly used pilot devices in motor-control circuits.

15. List two types of push-button stations:

- a. MAINTAINED CONTACT
- b. MOMENTARY CONTACT

16. Maintained-contact type push button operates motor-control by MECHANICAL LINKAGE.

17. Momentary contact type push button operates motor-control MAGNETICALLY.

18. Time clock SWITCHES open and close contacts at pre-determined times.

19. Quality should never be SACRIFICED in pilot devices.

PILOT DEVICES

DESIRED RESULTS:

1. To acquaint the student with the basic types of control components.
2. The student should be able to look at a strange control device and analyze its function both mechanically and electrically.

INTRODUCTION:

All components used in motor-control circuits are classed as either primary control devices or pilot control devices. A primary control device connects the load to the power line, such as a motor starter or controller; they may be manual or automatic. Pilot control devices are those which control or regulate the primary control devices. Pilot devices are such components as push buttons, float switches, pressure switches, limit switches, and thermostats. The most common and frequently used types will be covered in this lesson.

PRESENTING THE LESSON:

1. Describe various pilot devices and their uses. The requirements of pilot devices vary greatly with their function and their proposed use.
2. Demonstrate samples of pilot devices available. Show how they are installed and ways to "troubleshoot" when the unit will not function.
3. Invite a specialist that deals with motor controls and pilot devices to give a demonstration to the class.
4. Use Review Questions, found in AC Motor-Control Fundamentals for discussion.

APPLICATION:

Have the students complete the questions on the Assignment Sheets.

CHECKING AND FOLLOW-UP:

Check the answers on the Assignment Sheets and return to the students for correction.

CONTROL-CIRCUIT DIAGRAMS

DESIRED RESULTS:

To learn the basic symbols that are used on prints to express the meaning and purpose of the circuit.

INTRODUCTION:

Until the electrician masters the control diagrams, he will be dependent upon someone else for most of his information. This lesson deals with the written language of control and control circuits. It will be necessary for the apprentice to learn the basic symbols in order to understand the details of the schematic control diagrams. When we learned to read English, we first learned the 26 letters of the alphabet that are used to form all the words and sentences. The same thing is true in learning a graphical language. There are only a few basic symbols that are used to express the meaning and purpose of the control circuit.

PRESENTING THE LESSON:

1. Use Fig. 5-1, page 91, for a drill on recognizing the basic symbols.
2. The control diagram is the written language of control circuits; it takes several different forms to fit the needs. Study the three general types of control diagrams used in the text.
3. Show how a schematic diagram is developed from a wiring diagram. Wiring diagram from the schematic.
4. If possible, have available control-circuit diagrams used in the local area for review by the class.
5. Discuss the adding of circuit elements, such as a limit switch, float switch, or push button to an existing circuit.
6. Summarize the use of schematic and wiring diagrams as presented in this lesson.

APPLICATION:

Have the students complete the questions on the Assignment Sheets.

CHECKING AND FOLLOW-UP:

Check the sheets and return to the students for correction and filing.

NAME _____

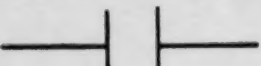
LESSON C-22

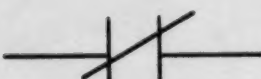
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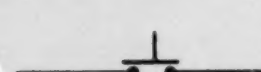
CONTROL-CIRCUIT DIAGRAMS

1. Describe the function of the following symbols:

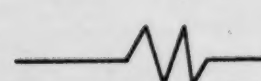
a.  N. O. CONTACT

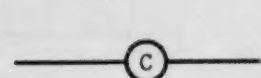
b.  N. C. CONTACT

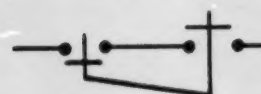
c.  STOP BUTTON

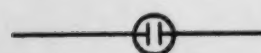
d.  START BUTTON

e.  HEATER ELEMENT

f.  RESISTOR

g.  COIL

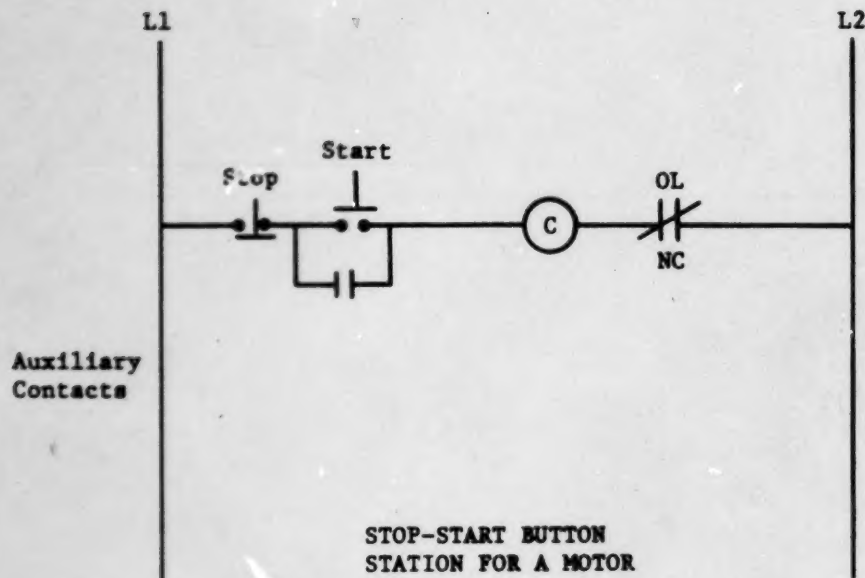
h.  N. O. PUSH BUTTON "2 CONTACT"

i.  CAPACITORS

2. The CONTROL DIAGRAM is the written language of control circuits.

3. List three general types of control diagrams:
 - a. WIRING
 - b. SCHEMATIC OR LINE
 - c. ONE LINE
4. A WIRING diagram is best suited drawing for making initial connections of a CONTROL SYSTEM.
5. A SCHEMATIC DIAGRAM is easiest drawing to understand.
6. A one- LINE DIAGRAM is compact and eliminates some confusion when many wires are indicated.
7. Wiring diagram is a drawing of the EQUIPMENT.
8. What is the chief advantage of the wiring diagram? HELPS TO IDENTIFY COMPONENTS AND WIRES AS THEY ARE FOUND ON EQUIPMENT
9. Most circuit diagrams are first developed by drawing a SCHEMATIC.
10. A wiring diagram is a representation of the CIRCUIT in its PROPER electrical sequence.
11. A SCHEMATIC DIAGRAM is read from left to right.
12. Symbols are used to identify RELAY COILS and CONTACTS in a schematic diagram.
13. How is a schematic diagram developed from a wiring diagram?
NUMBER ALL WIRES ON EACH END STARTING AT 11, THEN DRAW 2 VERTICAL LINES AND 1 HORIZONTAL ONE, THE HORIZONTAL LINE NUMBER EACH WIRE AS IT IS NUMBERED ON THE WIRING AND PUT SYMBOLS FOR EACH COMPONENT,
14. "Start" push buttons or components are connected in PARALLEL.
15. "Stop" push buttons or components are connected in SERIES.
16. The duty of device will determine whether it will be connected in SERIES or PARALLEL in a circuit.

17. Draw a one-line diagram showing symbols for a start-stop button station and starter for a motor.



DEVELOPMENT OF CONTROL CIRCUITS

DESIRED RESULTS:

1. To acquaint the student with the principles involved in the development of control circuits.
2. To have the student practice the development of a circuit adding one function at a time.

INTRODUCTION:

In the development of control circuits, they are seldom drawn or designed as a complete unit. They are developed one step at a time, adding only the components necessary to perform that function. The designer of a circuit should have all of the control functions in mind when he starts. He should analyze the circuit after each addition to check that it does not interfere with previous operations and that it will perform the function intended. The greatest danger in developing control circuits is to attempt to draw a complete circuit at one time. Therefore, it cannot be overstressed that the step-by-step method of developing control circuits will lead to very few errors. It will save many hours of "troubleshooting" trying to find out why a circuit did not function after it was wired.

PRESENTING THE LESSON:

1. Discuss the basic two-wire and three-wire circuits in the development of control circuits.
2. Using a schematic diagram, show the simplest method for the development of a control circuit by starting with the coil and the overloads.
3. Review with the students the development of illustrated circuits No. 1-8 given in the text.
4. Using the review questions, assign the problems for the students to develop. One problem for each student or one problem for two students to work together.

APPLICATION:

Have the students complete the problems on the Assignment Sheet.

CHECKING AND FOLLOW-UP:

Check the assignment sheets and return to the students for correction and placing in their workbooks.

NAME _____

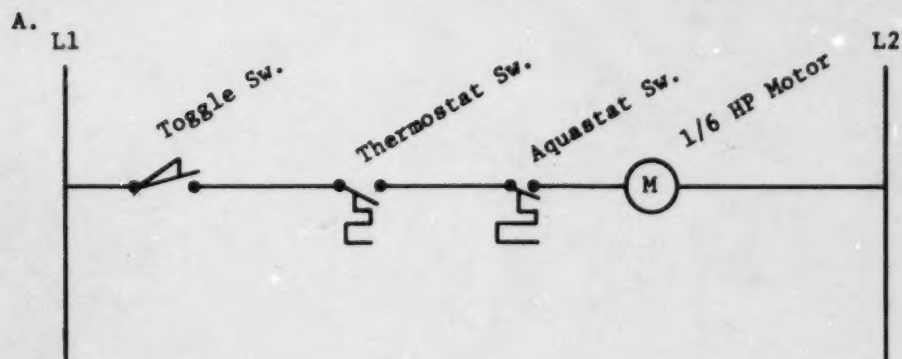
LESSON C-23

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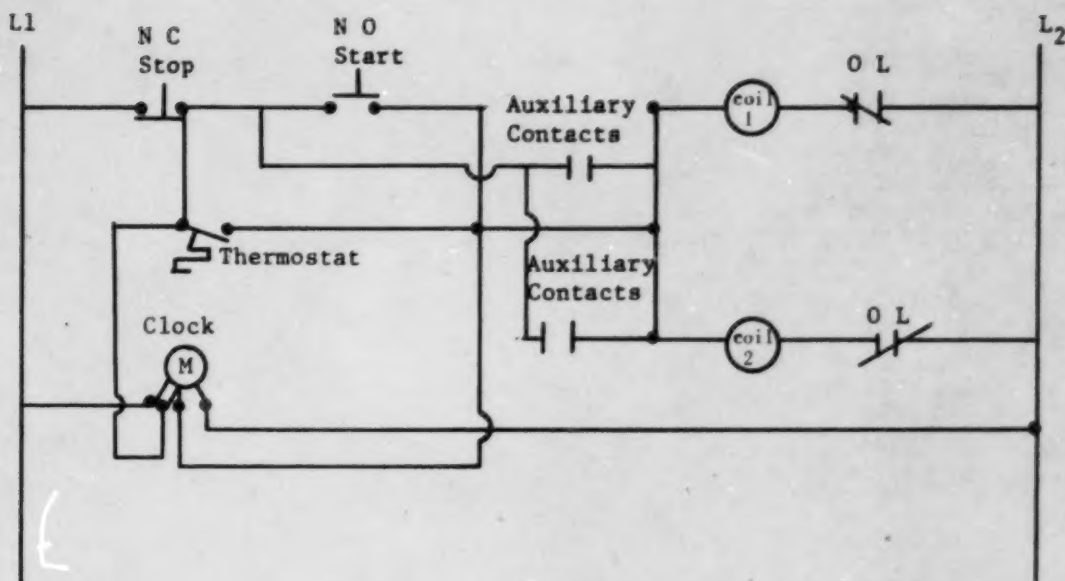
WORKSHEET

DEVELOPMENT OF CONTROL CIRCUITS

1. How are control circuits developed? ONE FUNCTION AT A TIME
2. List two basic types of control circuits:
 - a. THREE-WIRE
 - b. TWO-WIRE
3. Push buttons which are used on three-wire control circuits are called MOMENTARY - CONTACT.
4. Push buttons which are used on two-wire control circuits are called MAINTAINED - CONTACT.
5. Momentary-contacts control circuits provide LOW - VOLTAGE PROTECTION.
6. Draw a schematic control diagram 1/6 HP unit heater motor having a manual "Start-Stop" toggle switch, an "On-Off" thermostat and "On-Off" aquastat which requires the water to be a pre-determined temperature before the motor can operate.



7. Draw a schematic control diagram of two exhaust fans with magnetic starters, actuated by a remote "Start-Stop" push button, time switch or thermostat if the temperature in the room exceeds a pre-determined temperature.



MATERIAL TAKE-OFF

Listed below is the material required for the lighting and receptacle outlets:

- 11 Lighting outlet boxes
- 11 Bar hanger (with fixture stud)
- 18 Switch boxes w-nails (12 S.P. switches and 6 3-way switches)
- 19 Receptacle boxes w-nails

- 850' 14-2 Romex w/ground (12 lights, 17 receptacles)
(40 outlets x 20' each) (11 S.P. switches - 2 fans)

- 100' 12-2 Romex w/ground (3 receptacles in kitchen and
dining room) + GFI receptacles
in baths and outdoors
(3 outlets x 20' each)

- 90' 14-3 Romex w/ground (6 outlets x 15' each)

- 230 Romex staples (1040' total wire $\div$ 4.5' = 230)

- 75 Sta-kons or wire nuts (splices in boxes and fixture splices)
- 19 Duplex receptacles
- 3 GFI receptacles - I.W.P. (with Plates)
- 19 Duplex receptacle plates
- 11 Single pole switches
- 6 3-way switches
- 7 1-gang switch plates
- 5 2-gang switch plates
- 51 Bonding clips or screws to ground boxes
- 5 1/2" Romex connectors (for panel - 2 small appliance circuits,
3 general lighting circuits)
- 2 20 amp 1-pole breakers
- 3 15 amp 1-pole breakers

Listed below is the material required for the major appliance circuits and outlets:

Dishwasher

- 30' 12-2 Romex w/ground
- 6 Romex staples
- 1 Receptacle box w-nails
- 1 Receptacle (20 amp 115 volt)

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Dishwasher (Continued)

- 1 Receptacle plate
- 1 1/2" Romex connector (at panel)
- 1 20 amp 1-pole breaker

Refrigerator

- 20' 12-2 Romex w/ground
- 4 Romex staples
- 1 Receptacle box w-nails
- 1 Receptacle (20 amp 115 volt)
- 1 Receptacle plate
- 1 1/2" Romex connector (at panel)
- 1 20 amp 1-pole breaker

Washer

- 15' 12-2 Romex w/ground
- 4 Romex staples
- 1 Receptacle box w-nails
- 1 Receptacle (20 amp 115 volt)
- 1 Receptacle plate
- 1 1/2" Romex connector (at panel)
- 1 20 amp 1-pole breaker

Water Heater

- 20' 10-2 Romex w/ground
- 4 Romex staples
- 2 1/2" Romex connectors
- 2 Wire nuts
- 1 30 amp 2-pole breaker

Dryer

- 10' 10-3 Romex
- 2 Romex staples
- 1 Surface dryer receptacle
- 1 1/2" Romex connector
- 1 30 amp 2-pole breaker

Range

- 25' 6/3 service cable
- 6 Nail straps
- 1 Surface range receptacle

Range (Continued)

- 1 3/4" cable connector (at panel)
- 1 50 amp 2-pole breaker

Bathroom Exhaust Fans (on General Lighting Circuits)

- 4 1/2" Romex connectors
- 4 Wire nuts

Listed below is the material required for the baseboard heating system:

- 4 500 watt baseboard heaters
- 2 750 watt baseboard heaters
- 1 1000 watt baseboard heater
- 3 1500 watt baseboard heater
- 1 500 watt kick space heater
- 7 Switch boxes w-nails for thermostats
- 7 Line voltage heat thermostats (wall mounted)
- 11 Chase nipples or connectors for entering heaters
- 450' 12-2 Romex w/ground (18 outlets x 25' each)
(11 heaters + 7 thermostats)
- 100 Romex staples
- 44 Screws for fastening heater to walls
- 43 Sta-kons or wire nuts (heater connections and joints in thermostats)
- 3 1/2" Romex connectors (at panel)
- 3 20 amp 2-pole breakers

Listed below is the material required for the ceiling cable heating system:

- 2 1400 watt heat cable
- 1 200 watt heat cable
- 1 400 watt heat cable
- 1 1000 watt heat cable
- 1 2000 watt heat cable
- 1 3000 watt heat cable
- 5000 Heat cable staples (for fastening cable to lath or sheetrock)
- 7 Switch boxes w-nails for thermostats
- 7 Line voltage heat thermostats (wall mounted)
- 175' 12-2 Romex w/ground (7 thermostat outlets x 25' each)
- 50 Romex staples
- 21 Sta-kons or wire nuts (joints in thermostat)
- 3 1/2" Romex connectors (at panel)
- 3 20 amp 2-pole breakers

Listed below is the material required for the electric furnace heating system:

- 1 60 amp 2-pole breaker
- 25' 6/3 copper or 4/3 alum. service cable
- 2 3/4" service cable connectors
- 6 Nail straps
- 1 60 amp 2-pole no fuse disconnect switch
- 4 Screws to mount switch
- 3' 3/4" Greenfield (flexible metal conduit)
- 2 3/4" Greenfield connectors
- 10' #6 THHN wire
- 5' #10 THHN wire green (to bond around Greenfield)
- 20' 18-5 thermostat wire
- 4 Insulated staples

Listed below is the material required for the pad mounted A/C condenser unit:

- 1 30 amp 2-pole breaker
- 20' 10-2 Romex w/ground
- 5 Romex staples
- 2 1/2" Romex connectors
- 1 30 amp 2-pole no fuse raintight disconnect switch
- 4 Screws to mount switch
- 3' 1/2" liquid-tight Greenfield
- 2 1/2" liquid-tight Greenfield connectors
- 10' #10 THW wire
- 5' #10 THW wire (green) to bond around Greenfield
- 30' 18-2 thermostat wire (from furnace to condenser)

Listed below is the material required for the two window A/C units:

8,000 BTU 115 Volt

- 20' 12-2 Romex w/ground
- 4 Romex staples
- 1 Receptacle box w-nails
- 1 Receptacle (20 amp 115 volt)
- 1 Receptacle plate
- 1 1/2" Romex connector (at panel)
- 1 20 amp 1-pole breaker

15,000 BTU 230 Volt

- 20' 12-2 Romex w/ground
- 4 Romex staples

15,000 BTU 230 Volt (Continued)

- 1 Receptacle box w-nails
- 1 Receptacle (20 amp 230 volt)
- 1 Receptacle plate

- 1 1/2" Romex connector (at panel)
- 1 20 amp 2-pole breaker

Listed below is the material required for the service, panel, and grounding:

Panel

- 1 1-phase 3 wire with 125 amp main breaker and 24 1-pole breaker spaces

- 25' 3 conductor 125 amp service cable (3- 1/0 aluminum) or (3- #2 copper)

- 2 1 1/2" cable connectors
- 1 1 1/2" watertight cable connector (top of meter base)
- 1 Entrance cap or weatherhead
- 8 Service cable straps
- 16 Screws for straps and mounting panel and meter base

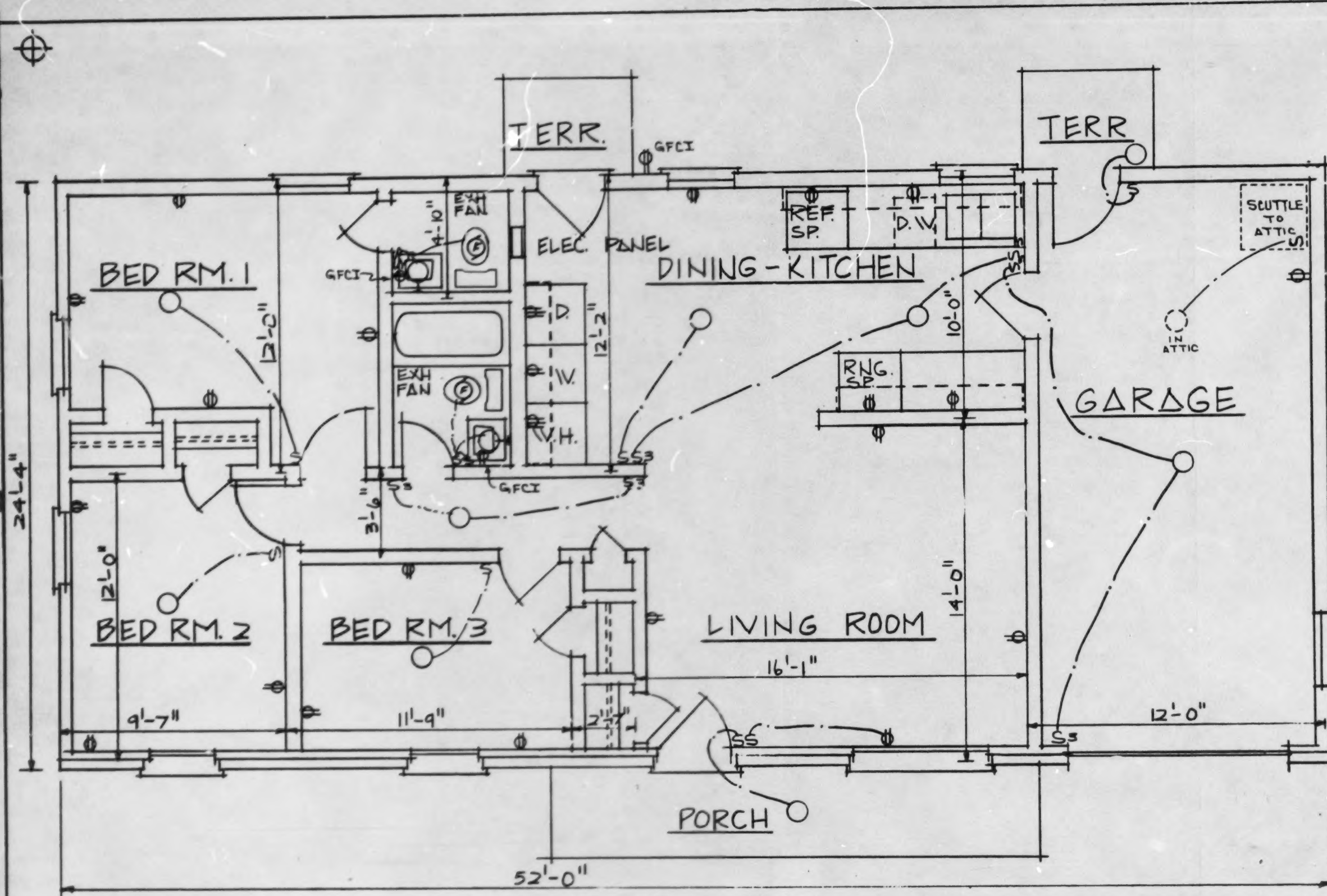
- 20' #6 bare copper wire for (grounding conductor from panel to cold water pipe) and (driven ground)
- 2 Ground clamps
- 1 8' ground rod

MATERIAL TAKE-OFF

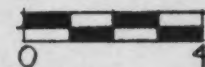
1. From the house plan, list the material you would need to rough the job in, trim it out, and leave it ready for occupancy. The owner will supply the fixtures. Material should be listed for the following general uses:
 - a. Lighting and receptacle outlets
 - b. Major appliance outlets
 - c. Heating system (one system only)
 - d. Air conditioning system (one method only)
 - e. Panel and service
2. Types of material to be listed should include:
 - a. Boxes
 - (1) Outlet - fixture stud
 - (2) Switch
 - (3) Receptacle
 - b. Cable - size and number of conductors
 - c. Devices and plates
 - d. Fastening materials - screws, anchors, straps, staples
 - e. Panel - size main bus, number and size of branches
 - f. Service - cable, grounding conductor, ground rod or pipe, entrance cap, meter box-pick up from utility

NOTE: These lists were circuited out and compiled by a contractor's estimator who specializes in single and multi-family dwellings. A student error of 10% would be considered reasonable due to a lack of experience.

No one student should need more than 5 of the eight material list categories to complete one method of total electric comfort conditioning the residence (i.e. only one method of heating and one method of cooling plus lighting and receptacle outlets, major appliance circuits, and the panel, service, and grounding).



FLOOR PLAN

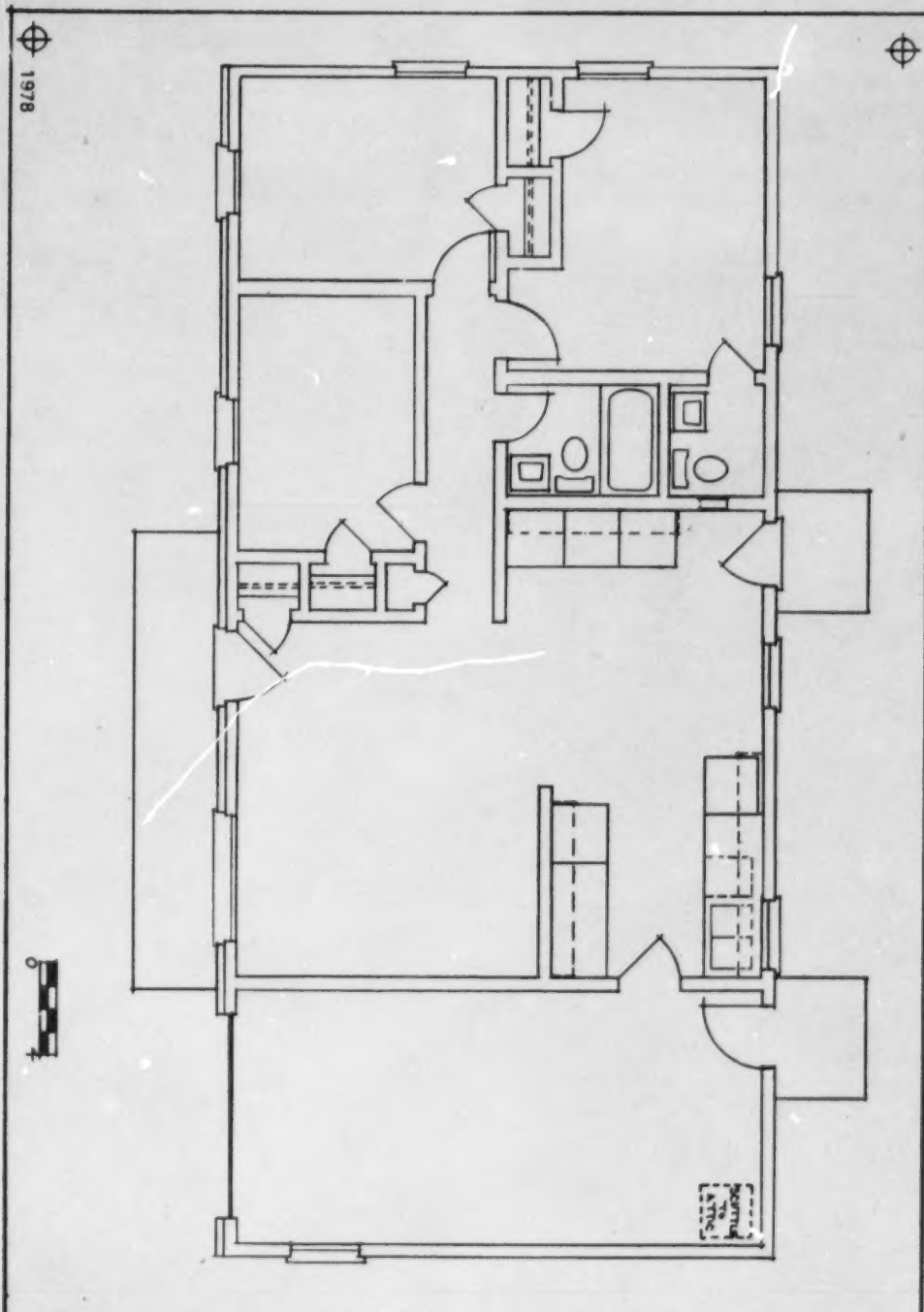


STUDENT: GARY ROBBINS
 STUDENT NO. 6248
 326 PINEVIEW ST
 ASHEBORO, N.C.
 SHEET NO. 1 OF 1

FLOOR PLAN

GUILFORD TECHNICAL
 INSTITUTE, JAMESTOWN NC

ARCHITECTURAL
 TECHNOLOGY DEPARTMENT



GUILFORD TECHNICAL INSTITUTE, JAMESTOWN, NC	FLOOR PLAN	STUDENT: GARY ROBBINS STUDENT NO. 6248 326 PINEVIEW ST.
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TERR.

TERR.

EXH
FAN.

ELEC. PANEL

REF.
SP.

D
W

BED RM. 1

DINING-KITCHEN

D

EXH
FAN.

W

RNG.
SP.

GARAGE

WH

BED RM. 2

BED RM. 3

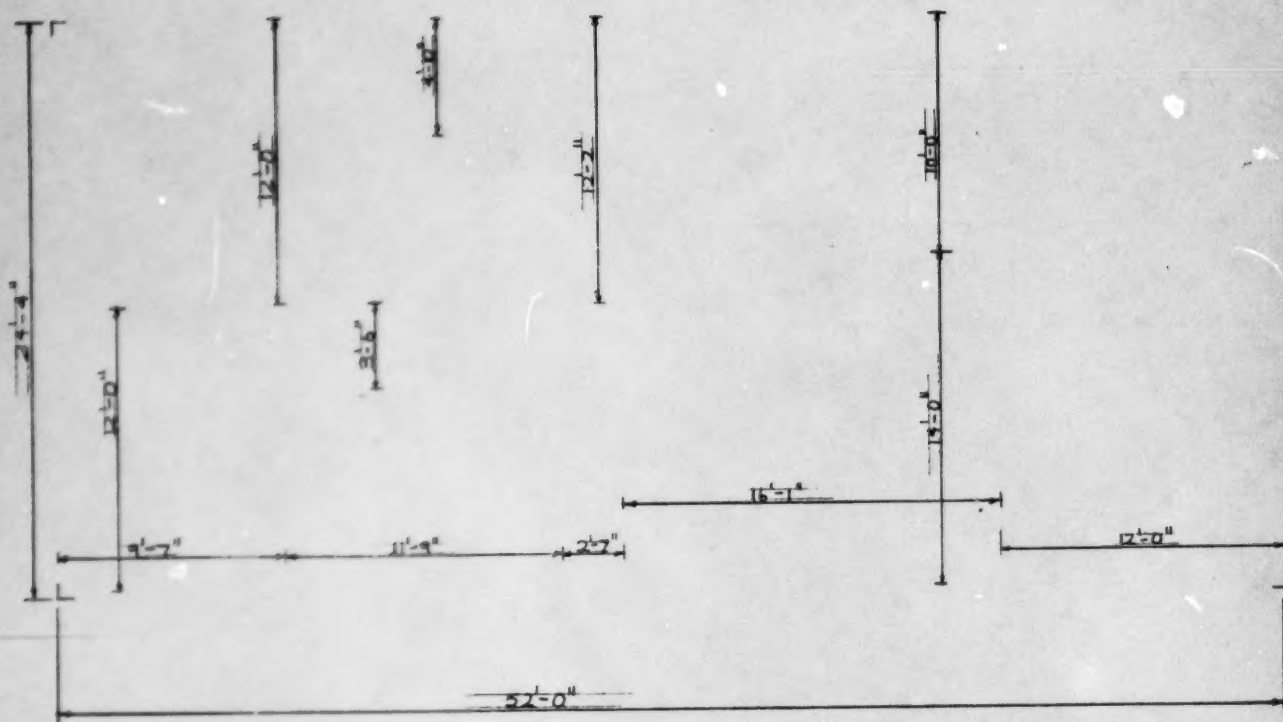
LIVING ROOM

PORCH

145



1978



1978

146



1978

147

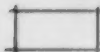


1978

8500 KW BASE BOARD HEAT
OR
(9400 KW CEILING CABLE HEAT)



20000 BTU
P&D CONDENSER...



10 KW ELECTRIC FURNACE
IN ATTIC SPACE

10 KW ELECTRIC FURNACE
WITH AIR CONDITIONER



1978



 ~~8000 BTU~~
~~AIR CONDITIONER~~

 ~~15000 BTU~~
~~AIR CONDITIONER~~

 1978

~~WINDOW AIR CONDITIONERS~~
~~2300 BTU~~

ESTIMATING

DESIRED RESULTS:

1. To present the major items used to estimate the cost of making a given electrical installation.
2. To discuss the methods of calculating the cost of materials, labor, tools, and equipment, etc. for various installations.
3. To appreciate the position of management to make good estimates of all items in installations in order to realize profits.

INTRODUCTION:

This unit is presented to give the apprentice an appreciation of costs involved in electrical installations rather than to teach how to make the calculations. Note that all of the items involved have some built-in variables, but generally it takes a set amount of materials to build a given electrical installation. Introduce some of the variables used in these estimates.

PRESENTING THE LESSON:

Discuss what is meant by an electrical installation estimate. List some of the items included in an estimate. Point out the items that make an accurate estimate. How is management able to make profits on these electrical installations?

Discuss the items that are deducted from a worker's check. Show why there are wide differences in "bid prices" submitted by contractors or companies. How do the companies calculate to realize profits on these jobs?

APPLICATION:

Have the students complete the worksheet for this lesson.

CHECKING AND FOLLOW-UP:

Check the answers in class and return the sheets to the students for filing in their notebooks.

ESTIMATING

An estimate is an accurate and factual appraisal of the probable cost of doing a job.

The cost of doing a job consists of a number of items; a few major ones are:

- | | |
|------------------------|----------------------------|
| a. Material | d. Bonds |
| b. Labor | e. Tools and equipment |
| c. Taxes and insurance | f. Job and office overhead |
| | g. Profit |

All of the above items have some built-in variations, but generally it takes a set amount of material to accomplish a given electrical job.

Once an accurate material list for a job is made, an estimate of the man-hours needed to install this work must be made. The tools and equipment needed to do the job must be figured into the estimate, along with taxes, insurance, bonds, and the non-production labor (office workers-payroll, billing, estimating, warehousemen, engineers, accounting, secretaries, salesmen, etc. who keep the wheels turning). To this list of figures is added profit.

Notice that an estimate is a group of variables stacked one upon another yet all based on the quantity of material necessary to make the electrical installation.

Your job as an electrician is to be able to take the material required to do the job and install it within the time allotted. You must be able to see the job from the plans the same way the engineer designed the job and as the estimator saw it when he took the job off the plans.

To install the work, you must know the many component parts which make up the complete installation--where they fit into the work, how they are fastened in place, and how to interconnect them electrically. Without all of this knowledge, the job cannot be done to fit the plans, the budget, the N. E. Code requirements, and the user's needs.

NAME _____

LESSON C-25

DATE _____

WORKSHEET

ESTIMATING

1. What are the seven major items in compiling a job estimate?

- | | |
|-------------------------------|-----------------------------------|
| a. <u>MATERIAL</u> | e. <u>TOOLS AND EQUIPMENT</u> |
| b. <u>LABOR</u> | f. <u>JOB AND OFFICE OVERHEAD</u> |
| c. <u>TAXES AND INSURANCE</u> | g. <u>PROFIT</u> |
| d. <u>BONDS</u> | |

2. Which of the above items is the key to an accurate estimate?

MATERIAL

3. Which of the above items are subject to the efficiency of the electrician?

- | | |
|-------------------------------|------------------|
| a. <u>LABOR</u> | c. <u>PROFIT</u> |
| b. <u>TOOLS AND EQUIPMENT</u> | |

4. Which of the above items is a known operating expense that most owners insist on having the contractor supply? PERFORMANCE BOND

5. Which of the above items is a known operating expense that the contractor must have to keep a smooth-running company?

JOB AND OFFICE OVERHEAD

6. What are the major items covered by taxes and insurance?

- | | |
|-------------------------------|----------------------------------|
| a. <u>STATE WITHHOLDING</u> | d. <u>WORKMAN'S COMPENSATION</u> |
| b. <u>FEDERAL WITHHOLDING</u> | e. <u>ACCIDENT INSURANCE</u> |
| c. <u>SOCIAL SECURITY</u> | |

7. Of all the items which make up the bid price of a job, which one is beyond the contractor's direct control? PROFIT

8. On a bid job which must be installed according to strict plans and specifications, why are there differences in bid prices? List three.

- a. THE EFFICIENCY OF THE CONTRACTORS ELECTRICIANS

- b. LOWER INSURANCE RATES FOR SAFETY-CONSCIENCE COMPANIES WITH LOW
CLAIMS AND FEW ACCIDENTS.

- c. PROPER USE OF TOOLS AND EQUIPMENT

ALTERNATE ANSWERS:

CONTRACTOR WILLING TO TAKE LESS PROFIT FOR JOB
MORE EFFICIENT AND SMALLER OFFICE AND JOB OVERHEAD
WISER USE OF MATERIALS

APPENDIX

155

NAME _____

DATE _____

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
THIRD YEAR - SERIES C
LESSON C-1 THRU C-4
TEST C-1

1. Alternating current or voltage is one which is reversed at REGULAR intervals.
2. A cycle is a complete set of VALUES through which an alternating current passes.
3. One cycle is equal to 360° electrical degrees. (180°, 270°, 360°)
4. The expression "60 cycle per second" means that the current referred to makes 60 complete cycles in a second. (60, 120, or 30)
5. Three-phase current is three different alternating currents 120° out of phase. True/False TRUE
6. Effective values of ALTERNATING CURRENT and voltage are the ones ordinarily referred to when speaking of alternating quantities.
7. The average value of alternating current or voltage is AVERAGE
OF THE INSTANTANEOUS VALUES FOR 1/2 CYCLE
and .636 times MAXIMUM VALUE.
8. The EFFECTIVE value of alternating current or voltage is 0.707 times MAXIMUM VALUE.
9. Effective power is equal to product of EFFECTIVE voltage and EFFECTIVE current.
10. Inductance produces OPPOSITION to flow of current and makes the current LAG the VOLTAGE.
11. List two factors which may cause an increase in resistance in A. C. circuits:
(a) INDUCTANCE (b) CAPACITANCE
12. EFFECTIVE values of A. C. voltage and current must be used in circuit laws and rules.
13. VOLTAGE and CURRENT are in phase in resistive circuits.
14. What is meant by the term "in phase"? CORRESPONDING VALUES
FOR CURRENT AND VOLTAGE ARE THE SAME AT ANY GIVEN TIME.
15. AVERAGE power is the actual power used in an A.C. circuit.

16. Power is equal to the product of VOLTS and AMPERES.
17. Power is expressed in terms of WATTS or VOLT AMPERES.
18. Resistance is expressed in terms of OHMS.
19. Power factor is expressed in PERCENT or DECIMALS.
20. Power factor is the ratios of WATTS of the circuit and VOLT AMPERES of the circuit.
21. Inductance exists because an electric current produces a COUNTER EMF.
22. Small current flow produces a SMALL magnetic field.
23. Inductance is produced only with a CHANGE in current.
24. In a D. C. circuit, inductance is produced only when the power is TURNED ON or TURNED OFF.
25. Unit of inductive reactance is OHM.
26. Symbol of inductive reactance is X_L.
27. In 60 cycle A. C. circuits, inductive reactance occurs 120 times per second.
28. PHASE ANGLE is the amount in degrees by which the current lags the voltage.
29. The letter symbol for capacitance is C.
30. The unit of capacitance is OHM.
31. Capacitance is the ABILITY of a circuit to store electrical energy.
32. In an A. C. circuit, a capacitor is constantly CHARGING and DISCHARGING.
33. The effect of capacitance in an A. C. circuit is that it produces OPPOSITION to the flow of CURRENT.
34. The opposition to alternating current produced by capacitance is CAPACITIVE REACTANCE.
35. Capacitive reactance is inversely proportioned to the product of the FREQUENCY and capacitance.

NAME _____

DATE _____

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
THIRD YEAR - SERIES C
LESSON C-5 THRU C-7
TEST C - 2

1. A synchronous CONDENSER is a synchronous motor used to correct power factor only and does not pull any MECHANICAL load.
2. Synchronous motors may be used to CORRECT low power factor of a system.
3. Lower power factors INCREASE the total current of a circuit.
4. Low power factor may be due to large power consumption by under-loaded INDUCTION motors.
5. The true POWER is the actual power which may be measured by a watt meter.
6. Power factor is the ratio of power in watts to power volt amperes, TRUE-APPARENT.
7. Capacitor cases shall be grounded in accordance with Article (A) 250.
(a) 250 (b) 460 (c) 680
8. The ampacity of capacitor circuit conductors shall be not less than (A) 135 percent of the rated current of the capacitor.
(a) 135 (b) 125 (c) 100
9. The continuous ampacity of the disconnecting device shall be not less than (c) 135 percent of the rated current of the capacitor.
(a) 100 (b) 125 (c) 135
10. For greater power factor correction effect, the capacitor should be located at the LOAD.
11. When can the disconnecting means be omitted at the capacitor? WHEN CONNECTED TO LOAD SIDE OF A MOTOR OVERCURRENT DEVICE.
12. The current carrying capacity of a disconnecting device shall be a minimum of 135 percent of the rated current of the capacitor.
13. An overcurrent device shall be installed in each UNGROUNDED conductor.
14. Are capacitor cases required to be grounded? YES
15. The power in any electrical circuit is the product of VOLTAGE and CURRENT flowing at that time.

NAME _____

TEST C-2

16. In a resistive circuit, power is found by multiplying the effective VOLTAGE by effective CURRENT.
17. Apparent POWER is the product of the voltage and current.
18. Apparent power units are in VOLT AMPERES.
19. True power units are measured in WATTS.
20. The ratio of true power to apparent power is called POWER
FACTOR.
21. In an inductive circuit, the reactive power LAGS the true power.
22. In a capacitive circuit, the reactive power LEADS the true power.
23. The currents in a three phase circuit will be 120 degrees out of phase with each other.

NAME _____
DATE _____

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
THIRD YEAR - SERIES C
LESSON C-8 THRU C-11
TEST C-3

1. Do Articles 500-517 apply to hazardous locations if intrinsically safe equipment and wiring is used? Yes/No NO. Give the N. E. Code Section to prove your answer. 500-1
2. Define "intrinsically safe" equipment. EQUIPMENT AND WIRING INCAPABLE OF RELEASING SUFFICIENT ELECTRICAL ENERGY UNDER NORMAL OR ABNORMAL CONDITIONS TO CAUSE IGNITION
3. Define the three classes of hazardous locations:
 - I. FLAMMABLE GASES OR VAPORS
 - II. COMBUSTIBLE DUST
 - III. EASILY IGNITABLE FIBERS OR FLYINGS
4. Where may hazardous materials be found in a Division 1 area?
FREELY PRESENT IN AIR
5. Where may hazardous materials be found in a Division 2 area?
NORMALLY CONFINED TO CONTAINERS
6. What is the intent of Article 500 through 503? TO REQUIRE A FORM OF CONSTRUCTION OF EQUIPMENT AND OF INSTALLATION THAT WILL INSURE SAFE PERFORMANCE UNDER CONDITIONS OF PROPER USE AND MAINTENANCE.
7. All boxes, fittings, and joints shall be THREADED and shall be EXPLOSION PROOF in Class I, Division 1 locations.
8. What is the purpose of using seals? TO PREVENT PASSAGE OF GASES FROM ONE PART OF ELECTRICAL SYSTEM TO ANOTHER.
9. Seals shall not exceed 18 inches from enclosure in Class I, Division 1 locations.
10. Are seals required in conduits less than 2 inches diameter in Class I, Division 1 locations? YES
11. In conduits leaving Class I, Division 1 areas, seals may be installed either INSIDE or OUTSIDE the hazardous area.
12. If the seal is installed inside the hazardous area of a Class I, Division 1 location, there shall be no UNION, COUPLING, BOX, or FITTING in conduit between seal fitting and the point at which the conduit leaves the hazardous area.

13. Splices and TAPS shall not be made in sealing fittings.
14. Stems for pendant fixtures in Class I, Divisions 1 and 2 locations shall not exceed 12 inches without permanent bracing.
15. List two requirements for using receptacles in Class I, Divisions 1 and 2 locations:
- (a) PLUG DOES NOT INTERRUPT CURRENT
- (b) PLUG IS LOCKING AND GROUNDING TYPE
16. All exposed non-current-carrying metal parts of electrical equipment shall be GROUNDING in Class I, Divisions 1 and 2 locations.
17. Fitting and boxes in Class II, Division 1 areas shall be DUST - IGNITION proof and approved for CLASS II locations.
18. List two wiring methods where seals may be omitted in Class II, Divisions 1 and 2 areas:
- (a) HORIZONTAL RUN OF CONDUIT AT LEAST 10 FT. LONG
- (b) VERTICAL RUN OF CONDUIT AT LEAST 5 FT. LONG
19. Motors in Class II, Division 1 areas shall be TOTALLY ENCLOSED nonventilated and shall be approved as DUST - IGNITION PROOF for CLASS I locations.
20. Lighting fixtures for Class II, Division 1 areas shall be DUST - IGNITION PROOF approved for Class II installation.
21. On chain-mounted pendant fixtures, SEALS shall be installed at the entrance of cord with outlet box and fixture.
22. List two conditions which a lighting fixture is acceptable in a Class II, Division 2 area even though it is not approved for a Class II installation:
- (a) DESIGNED TO MINIMIZE DEPOSIT OF DUST ON LAMPS AND PREVENT SPARKS, BURNING MATERIAL, OR HOT METAL
- (b) DOES NOT EXCEED MAXIMUM SURFACE TEMPERATURE OF 165°C (329°F) UNDER NORMAL CONDITIONS OF USE

NAME _____

TEST C-3

23. List two requirements for installing receptacles and plugs in Class II, Division 1 areas:
- (a) DUST-IGNITION PROOF
 - (b) CAP AND PLUG CONNECTED TO GROUNDING CONDUCTOR OF CORD
24. Bonding JUMPERS shall be installed for bonding purposes in Class II, Divisions 1 and 2 installations.
25. Class III locations are hazardous due to the presence of IGNITABLE DUSTS and FLYINGS.
26. Flexible connections shall be made with DUST - TIGHT connectors in Class III, Division I and II areas.
27. Electric - DISCHARGE lighting fixtures with guard may be installed in Class III locations.
28. List two conditions for receptacles and plugs for Class III areas:
- (a) GROUNDING
 - (b) MAKE/BREAK NOT COMPLETELY EXPOSED
29. In general, TOTALLY enclosed motors shall be installed in all Class III areas.
30. List two requirements for construction of lighting fixtures in Class III areas:
- (a) DUST-TIGHT
 - (b) RETAIN EXPLOSION WITHIN FIXTURE

NAME _____
DATE _____

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
THIRD YEAR - SERIES C
LESSON C-12 THRU C-17
TEST C-4

1. Each floor up to 12 above the floor is considered Class I Division II unless mechanical ventilation provides a minimum of 4 air changes per hour.
2. Pits and depressions below floor level shall be considered Class I Division I locations. If 6 air changes per hour are exhausted at the floor level of the pit, it may be classified as a Class I Division II location.
3. Can a wire-guard drop cord with switch and receptacle be used in a commercial garage? NO Answer is found in article 511-2.
4. Conduit seal-offs (are-are not) ARE required in commercial garage areas, with in the horizontal and VERTICLE boundaries of the defined hazardous areas.
5. List 6 types of wiring methods which may be used above hazardous areas:
 - a. METALLIC RACEWAYS
 - b. MI CABLE
 - c. TC CABLE
 - d. SNM CABLE
 - e. MC CABLE
 - f. RIGID NON-METALLIC RACEWAYS
6. Receptacles in non-hazardous areas shall be of POLARIZING type.
7. Battery CHARGING equipment shall not be located within the hazardous area.
8. Can electric vehicles be charged in a commercial storage garage?
Yes/No YES Give the code section 511-8.
9. Flexible cords shall have:
 - a. Approval for EXTRA HARD usage.
 - b. Adequate AMPACITY for charging current.
 - c. Connector rating of no less than 50 amperes.
 - d. Connector will DISCONNECT readily at any position.
10. The entire hangar floor up to a level 18 inches above the floor is considered to be Class I, Division II, area.
11. The area 5'-0" above an aircraft wing is considered a Class I Division II, area.
12. Any area within 5 feet of an aircraft is considered hazardous.

NAME _____

Test C-4

13. All metallic raceways and non-current-carrying parts of fixed equipment or portable equipment regardless of voltage shall be GROUND.
14. Aircraft energizers shall have automatic controls to ISOLATE the ground power unit electrically in case excessive VOLTAGE is generated.
15. Does portable mobile service equipment operate near aircraft which operates at a low voltage have to be grounded? YES Give N. E. Code section for your answer. 513-12
16. What locations shall be included in the classifications?
WHERE GASOLINE OR OTHER VOLATILE FLAMMABLE LIQUIDS OR GASES ARE TRANSFERRED TO FUEL TANKS OF SELF-PROPELLED VEHICLES.
17. Any area located within 20 feet of the gasoline dispenser area shall be classified Class I, Division II.
18. What classification of hazardous area extends to 18 inches above drive? CLASS I, DIVISION II
19. What are the classification and limits around the tank fill pipe?
CLASS I, DIVISION II, WITHIN 10 FT. RADIUS AND 18" ABOVE GROUND
CLASS I, DIVISION I, BELOW GRADE
20. Circuit breakers shall be capable of disconnecting all SUPPLY conductors including the NEUTRAL simultaneously on circuits to dispensers.
21. Seals shall be installed in all conduits entering or leaving DISPENSING pump or other enclosures located in Class I, Division I or II, when connecting conduit originates in a NON - HAZARDOUS location.
22. The first fitting in a dispenser after the conduit emerges from the concrete slab shall be a SEAL-OFF.
23. What electrical equipment must be grounded under this article?
a. DISPENSING PUMPS METALLIC PARTS
b. METALLIC RACEWAYS
c. NON-CURRENT CARRYING PARTS OF ELECTRICAL EQUIPMENT
24. Does all underground wiring have to be in rigid metal conduit?
NO Give Code section for your answer. 514-8
25. The immediate area within 5 feet horizontally and vertically above the pump shall be classified as Class I, Division I.

NAME _____

TEST C-4

26. List restrictions and classification for an unventilated gasoline pump.
- a. CLASS I, DIVISION I, 5 FT. IN ALL DIRECTIONS
 - b. CLASS I, DIVISION I, 25 FT. HORIZONTALLY - 5 FT. ABOVE GRADE
 - c. CLASS I, DIVISION II, 5 FT. VERTICALLY-ABOVE GRADE OR FLOOR
27. Underground plastic conduit or duct may be installed in a hazardous area of buried 2 feet or more below grade.
28. Buried raceways under defined hazardous areas shall be considered to be WITHIN the hazardous area.
29. What are the three main methods of applying finishes?
- a. SPRAYING
 - b. DIPPING
 - c. BRUSHING
30. What are the hazardous substances involved in applying finishes?
- | | |
|--------------------|------------------------------|
| a. <u>PAINT</u> | d. <u>THINNER</u> |
| b. <u>LACQUER</u> | e. <u>IGNITABLE DEPOSITS</u> |
| c. <u>SOLVENTS</u> | f. <u>RESIDUES</u> |
31. The hazardous classification of Class I, Division I, covers areas within 20 feet horizontally and 10 ft. vertically of paint spray booths.
32. The hazardous classification of Class I, Division I, covers areas within 20 feet horizontally of dip tank and their drain boards.
33. The hazardous classification of Class I, Division II, covers the area beyond the limits of Class I, Division I, around paint spray booths and dip tanks.
34. What two requirements must be met for an area utilizing drying, curing, or fusion apparatus to be classified as non-hazardous?
- a. POSITIVE MECHANICAL VENTILATION
 - b. INTERLOCKS TO STOP ELECTRICAL EQUIPMENT IF VENTILATION EQUIPMENT IS INOPERATIVE.

NAME _____

TEST C-4

35. Give the five conditions which must be met to put a lighting fixture behind a panel of glass or other translucent material.

- a. FIXED LIGHTING UNITS ARE USED
- b. THE PANEL ISOLATES THE FIXTURE FROM THE HAZARDOUS AREA
- c. THE FIXTURE IS APPROVED FOR ITS LOCATION
- d. THE PANEL MATERIAL IS PROTECTED AGAINST BREAKAGE
- e. RESIDUE ON THE PANEL WILL NOT BECOME IGNITED BY HEAT FROM THE FIXTURE

36. What four conditions will shut down an electrostatic spraying operation to prevent danger to the operator or a fire from starting?

- a. FAILURE OF VENTILATING SYSTEM
- b. CONVEYER STOPPING IN HIGH-VOLTAGE FIELD
- c. A GROUND IN THE HIGH-VOLTAGE SYSTEM
- d. UNSAFE CLEARANCE BETWEEN ELECTRODES AND OBJECT BEING PAINTED

37. Article 517 of the N.E. Code contains 10 parts. List 10 of them and what they cover.

- a. GENERAL-SCOPE & DEFINITIONS
- b. WIRING SYSTEMS-GENERAL
- c. CLINICS, MEDICAL & DENTAL OFFICES & OUT-PATIENT FACILITIES
- d. NURSING HOMES & RESIDENTIAL CUSTODIAL CARE FACILITIES
- e. HOSPITALS
- f. PATIENT CARE AREAS
- g. INHALATION ANESTHETIZING LOCATIONS
- h. COMMUNICATIONS, SIGNAL SYSTEMS, DATA SYSTEMS, FIRE PROTECTIVE SIGNALING SYSTEMS, AND LOW-VOLTAGE SYSTEMS.
- i. THERAPEUTIC HIGH-FREQUENCY EQUIPMENT
- j. X-RAY EQUIPMENT

38. In a health care facility, what are the two main divisions of the emergency system?

- a. LIFE SAFETY BRANCH
- b. CRITICAL BRANCH

39. What are the emergency system branches of a nursing home or residential custodial care facility?

- a. LIFE SAFETY BRANCH
- b. CRITICAL BRANCH

40. Feeders and branches of the above emergency systems shall be INDEPENDENT (OR SEPARATE) from all other wiring systems.

41. All branches of the emergency system shall be restored to operation within 10 seconds of a power interruption.

NAME _____

TEST C-4

42. In patient care areas, what are the minimum requirements for an equipment grounding conductor.

a. Size	<u>#10 AWG</u>
b. Material	<u>COPPER</u>
c. Construction	<u>STRANDED WIRE</u>
d. Installation	<u>RUN WITH CIRCUIT CONDUCTORS</u>
e. Bonding	<u>TO PATIENT REFERENCE GROUNDING POINT</u>

43. Conduits in block walls in an anesthetics area are in a HAZARDOUS area.

44. List three types of wiring permitted in a hazardous area.

a. <u>METAL RACEWAYS</u>	c. <u>ALS CABLE</u>	e. <u>MC CABLE</u>
b. <u>MI CABLE</u>	d. <u>CS CABLE</u>	

45. Each circuit shall be supplied from an UNGROUNDED distribution system.

46. List three methods used for circuit isolation:

a. <u>TRANSFORMERS</u>	c. <u>SUITABLY ISOLATED BATTERIES</u>
b. <u>MOTOR GENERATORS</u>	

47. Secondary voltage of an isolation transformer shall not exceed 300 volts.

48. Primary voltage to isolation transformer shall not exceed 300 volts.

49. Overcurrent PROTECTION shall be installed in secondary neutral of isolation transformer.

50. Current through the ground indicator shall not exceed 2 MILLI-amperes.

NAME _____

DATE _____

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
THIRD YEAR - SERIES C
LESSON C-18 THRU C-23
TEST C - 5

1. A. Match Column B with Column A:

	<u>Column A</u>	<u>Column B</u>
<u>E</u>	1. A requirement of service at constant load for an unlimited period.	a. Automatic
<u>C</u>	2. Basic functions are performed by hand.	b. Motor control
<u>F</u>	3. These items are used on large horsepower motors.	c. Manual controller
<u>D</u>	4. The type of control that is used when we have a magnetic starter on a push button "Stop-Start" switch controlling motor.	d. Semi-automatic
<u>A</u>	5. Controls eliminates the necessity of a manual control.	e. Continuous duty
<u>B</u>	6. Means the governing or regulating the functions of a motor or machine.	f. Compensators
<u>H</u>	7. What is the most popular manual controller.	g. Drum switch
		h. Full-voltage

B. Answer the following:

What is the purpose of a master switch?

IT SERVES TO GOVERN THE OPERATION OF CONTACTORS AND AUXILIARY DEVICES OF AN ELECTRIC CONTROLLER.

What is the purpose of overload protection in a motor circuit?

INTERRUPTS THE CIRCUIT AT EXCESSIVE CURRENTS BUT NOT SHORT CIRCUIT CURRENTS.

Why are relays used?

LET ONE ELECTRICAL CIRCUIT CAUSE THE OPERATION OF OTHER DEVICES IN THE SAME CIRCUIT OR OTHER ELECTRICAL CIRCUITS.

How does a phase failure device operate?

IT FUNCTIONS ON A REDUCTION OR FAILURE OF VOLTAGE, TO CAUSE THE INTERRUPTION OF POWER IN A MOTOR CIRCUIT.

NAME _____

TEST C-5

2. List two "methods of stopping" a motor.
 - a. MANUALLY
 - b. AUTOMATICALLY
3. How is phase-failure protection provided? BY USING THREE OVERLOAD
RELAY UNITS
4. When does single phase occur in a three-phase motor? WHEN YOU
HAVE A CURRENT INTERRUPTION ON ONE PHASE
5. What type pilot devices provide an under-voltage protection?
MOMENTARY CONTACT
6. List three means of short-circuit protection.
 - a. FUSE
 - b. CIRCUIT BREAKER
 - c. MOTOR SHORT-CIRCUIT
PROTECTOR
7. Interlock in a starter may be accomplished by ELECTRICAL or
MECHANICAL connection.
8. What is the most popular starter used? ACROSS THE LINE
MAGNETIC
9. List the six main components of an automatic synchronous motor starter:
 - a. AUTOMATIC REDUCED VOLTAGE
STARTER
 - b. FIELD APPLICATION RELAY
 - c. FIELD DISCHARGE RESISTOR
 - d. OVERLOAD PROTECTION
 - e. UNDER VOLTAGE PROTECTION
 - f. CONTACTOR
10. The most critical component in a synchronous motor starter is the
FIELD - APPLICATION relay.
11. List seven main components of a semi-automatic synchronous motor
starter:
 - a. MANUAL COMPENSATOR
 - b. FIELD APPLICATION RELAY
 - c. FIELD RHEOSTAT
 - d. FIELD DISCHARGE RESISTOR
 - e. CONTACTOR
 - f. OVERLOAD PROTECTION
 - g. UNDER VOLTAGE PROTECTION

NAME _____

TEST C-5

12. List the five main components of a wound-rotor motor starter:

- | | |
|------------------------------------|--------------------------------|
| a. <u>FULL VOLTAGE STARTER</u> | d. <u>SECONDARY CONTROLLER</u> |
| b. <u>OVERLOAD PROTECTION</u> | e. <u>DRUM CONTROLLER</u> |
| c. <u>UNDER VOLTAGE PROTECTION</u> | |

13. A relay COIL requires a low current for functioning and may be used to CONTROL circuits of larger currents.

14. List five types of relays:

- | | |
|---------------------|--------------------|
| a. <u>VOLTAGE</u> | d. <u>TIME</u> |
| b. <u>CURRENT</u> | e. <u>OVERLOAD</u> |
| c. <u>FREQUENCY</u> | |

15. List three types of overload relays:

- | | |
|----------------------|--------------------|
| a. <u>RATCHET</u> | c. <u>MAGNETIC</u> |
| b. <u>BIMETALLIC</u> | |

16. Thermal relays trip on heat and are called COMPENSATED OVERLOAD relays.

17. A MAGNETIC motor starter closes the line contacts magnetically.

18. Magnetic starters for multispeed motors must have a CONTACTOR for each speed.

19. Motor-control circuit components may be classified as PRIMARY CONTROL devices or PILOT CONTROL devices.

20. Pilot control devices CONTROL or MODULATE primary control devices.

21. A magnetic starter is a PRIMARY CONTROL device.

22. List four types of pilot devices:

- | | |
|-----------------------|---------------------------|
| a. <u>PUSH BUTTON</u> | c. <u>PRESSURE SWITCH</u> |
| b. <u>FLOAT</u> | d. <u>THERMOSTAT</u> |

23. Overload RELAYS are pilot devices.

24. Pilot DEVICES are sensing devices.

NAME _____

TEST C-5

25. List three types of thermostats:
- a. BELLOWS
 - b. BIMETALLIC
 - c. MODULATING
26. Push- BUTTON STATION is most commonly used pilot devices in motor-control circuits.
27. List two types of push-button stations:
- a. MAINTAINED CONTACT
 - b. MOMENTARY CONTACT
28. Maintained-contact type push button operates motor-control by MECHANICAL LINKAGE.
29. Momentary contact type push button operates motor-control MAGNETICALLY.
30. The CONTROL DIAGRAM is the written language of control circuits.
31. List three general types of control diagrams:
- a. WIRING
 - b. SCHEMATIC OR LINE
 - c. ONE LINE
32. A WIRING diagram is best suited drawing for making initial connections of a CONTROL SYSTEM.
33. A SCHEMATIC DIAGRAM is easiest drawing to understand.
34. What is the chief advantage of the wiring diagram? HELPS TO IDENTIFY COMPONENTS AND WIRES AS THEY ARE FOUND ON EQUIPMENT
35. "Start" push buttons or components are connected in PARALLEL.
36. "Stop" push buttons or components are connected in SERIES.
37. How are control circuits developed? ONE FUNCTION AT A TIME
38. List two basic types of control circuits:
- a. THREE-WIRE
 - b. TWO-WIRE

NAME _____

TEST C-5

39. Push buttons which are used on three-wire control circuits are called MOMENTARY - CONTACT.
40. Push buttons which are used on two-wire control circuits are called MAINTAINED - CONTACT.
41. Momentary-contacts control circuits provide LOW - VOLTAGE
PROTECTION.

NAME _____

DATE _____

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
THIRD YEAR - SERIES C
LESSON C-1 THRU C-4
TEST C-1

1. Alternating current or voltage is one which is reversed at _____ intervals.
2. A cycle is a complete set of _____ through which an alternating current passes.
3. One cycle is equal to _____ electrical degrees. (0° , 90° , 180° , 270° , 360°)
4. The expression "60 cycle per second" means that the current referred to makes _____ complete cycles in a second. (60, 120, or 30)
5. Three-phase current is three different alternating currents 120° out of phase. True/False _____
6. Effective values of _____ and voltage are the ones ordinarily referred to when speaking of alternating quantities.
7. The average value of alternating current or voltage is _____ and _____ times _____.
8. The _____ value of alternating current or voltage is _____ times _____.
9. Effective power is equal to product of _____ voltage and _____ current.
10. Inductance produces _____ to flow of current and makes the current _____ the _____.
11. List two factors which may cause an increase in resistance in A. C. circuits:
(a) _____ (b) _____
12. _____ values of A. C. voltage and current must be used in circuit laws and rules.
13. _____ and _____ are in phase in resistive circuits.
14. What is meant by the term "in phase"? _____

15. _____ power is the actual power used in an A.C. circuit.

NAME _____

TEST C-1

16. Power is equal to the product of _____ and _____.
17. Power is expressed in terms of _____ or _____.
18. Resistance is expressed in terms of _____.
19. Power factor is expressed in _____ or _____.
20. Power factor is the ratios of _____ of the circuit and _____ of the circuit.
21. Inductance exists because an electric current produces a _____.
22. Small current flow produces a _____ magnetic field.
23. Inductance is produced only with a _____ in current.
24. In a D. C. circuit, inductance is produced only when the power is _____ or _____.
25. Unit of inductive reactance is _____.
26. Symbol of inductive reactance is _____.
27. In 60 cycle A. C. circuits, inductive reactance occurs _____ times per second.
28. _____ is the amount in degrees by which the current lags the voltage.
29. The letter symbol for capacitance is _____.
30. The unit of capacitance is _____.
31. Capacitance is the _____ of a circuit to store electrical energy.
32. In an A. C. circuit, a capacitor is constantly _____ and _____.
33. The effect of capacitance in an A. C. circuit is that it produces _____ to the flow of _____.
34. The opposition to alternating current produced by capacitance is _____.
35. Capacitive reactance is inversely proportioned to the product of the _____ and capacitance.

NAME _____

TEST C-1

36. Phase angle is the amount in degrees by which the current _____
the voltage.

NAME _____

DATE _____

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
THIRD YEAR - SERIES C
LESSON C-5 THRU C-7
TEST C - 2

1. A synchronous _____ is a synchronous motor used to correct power factor only and does not pull any _____ load.
2. Synchronous motors may be used to _____ low power factor of a system.
3. Lower power factors _____ the total current of a circuit.
4. Low power factor may be due to large power consumption by under-loaded _____ motors.
5. The true _____ is the actual power which may be measured by a watt meter.
6. Power factor is the ratio of power in watts to power volt amperes, _____.
7. Capacitor cases shall be grounded in accordance with Article _____.
(a) 250 (b) 460 (c) 680
8. The ampacity of capacitor circuit conductors shall be not less than _____ percent of the rated current of the capacitor.
(a) 135 (b) 125 (c) 100
9. The continuous ampacity of the disconnecting device shall be not less than _____ percent of the rated current of the capacitor.
(a) 100 (b) 125 (c) 135
10. For greater power factor correction effect, the capacitor should be located at the _____.
11. When can the disconnecting means be omitted at the capacitor? _____

12. The current carrying capacity of a disconnecting device shall be a minimum of _____ percent of the rated current of the capacitor.
13. An overcurrent device shall be installed in each _____ conductor.
14. Are capacitor cases required to be grounded? _____
15. The power in any electrical circuit is the product of _____ and _____ flowing at that time.

NAME _____

TEST C-2

16. In a resistive circuit, power is found by multiplying the effective _____ by effective _____.
17. Apparent _____ is the product of the voltage and current.
18. Apparent power units are in _____.
19. True power units are measured in _____.
20. The ratio of true power to apparent power is called _____.
21. In an inductive circuit, the reactive power _____ the true power.
22. In a capacitive circuit, the reactive power _____ the true power.
23. The currents in a three phase circuit will be _____ degrees out of phase with each other.

NAME _____

DATE _____

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
THIRD YEAR - SERIES C
LESSON C-8 THRU C-11
TEST C-3

1. Do Articles 500-517 apply to hazardous locations if intrinsically safe equipment and wiring is used? Yes/No _____. Give the N. E. Code Section to prove your answer. _____
2. Define "intrinsically safe" equipment. _____

3. Define the three classes of hazardous locations:
I. _____
II. _____
III. _____
4. Where may hazardous materials be found in a Division 1 area?

5. Where may hazardous materials be found in a Division 2 area?

6. What is the intent of Article 500 through 503? _____

7. All boxes, fittings, and joints shall be _____ and shall be _____ in Class I, Division 1 locations.
8. What is the purpose of using seals? _____

9. Seals shall not exceed _____ inches from enclosure in Class I, Division 1 locations.
10. Are seals required in conduits less than 2 inches diameter in Class I, Division 1 locations? _____
11. In conduits leaving Class I, Division 1 areas, seals may be installed either _____ or _____ the hazardous area.
12. If the seal is installed inside the hazardous area of a Class I, Division 1 location, there shall be no _____, _____, _____, or _____ in conduit between seal fitting and the point at which the conduit leaves the hazardous area.

NAME _____

TEST C-3

13. Splices and _____ shall not be made in sealing fittings.
14. Stems for pendant fixtures in Class I, Divisions 1 and 2 locations shall not exceed _____ inches without permanent bracing.
15. List two requirements for using receptacles in Class I, Divisions 1 and 2 locations:
- (a) _____
- (b) _____
16. All exposed non-current-carrying metal parts of electrical equipment shall be _____ in Class I, Divisions 1 and 2 locations.
17. Fitting and boxes in Class II, Division 1 areas shall be _____ - _____ proof and approved for _____ locations.
18. List two wiring methods where seals may be omitted in Class II, Divisions 1 and 2 areas:
- (a) _____
- (b) _____
19. Motors in Class II, Division 1 areas shall be _____ nonventilated and shall be approved as _____ - _____ for _____ locations.
20. Lighting fixtures for Class II, Division 1 areas shall be _____ - _____ approved for Class _____ installation.
21. On chain-mounted pendant fixtures, _____ shall be installed at the entrance of cord with outlet box and fixture.
22. List two conditions which a lighting fixture is acceptable in a Class II, Division 2 area even though it is not approved for a Class II installation:
- (a) _____
- (b) _____

NAME _____

TEST C-3

23. List two requirements for installing receptacles and plugs in Class II, Division 1 areas:
- (a) _____
- (b) _____
24. Bonding _____ shall be installed for bonding purposes in Class II, Divisions 1 and 2 installations.
25. Class III locations are hazardous due to the presence of _____ and _____.
26. Flexible connections shall be made with _____ - _____ connectors in Class III, Division _____ and _____ areas.
27. Electric - _____ lighting fixtures with guard may be installed in Class III locations.
28. List two conditions for receptacles and plugs for Class III areas:
- (a) _____
- (b) _____
29. In general, _____ enclosed motors shall be installed in all Class III areas.
30. List two requirements for construction of lighting fixtures in Class III areas:
- (a) _____
- (b) _____

NAME _____

DATE _____

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
THIRD YEAR - SERIES C
LESSON C-12 THRU C-17
TEST C-4

1. Each floor up to _____ above the floor is considered Class _____ Division _____ unless mechanical ventilation provides a minimum of _____ air changes per hour.
2. Pits and depressions below floor level shall be considered Class _____ Division _____ locations. If _____ air changes per hour are exhausted at the floor level of the pit, it may be classified as a Class _____ Division _____ locations.
3. Can a wire-guard drop cord with switch and receptacle be used in a commercial garage? _____ Answer is found in article _____.
4. Conduit seal-offs (are-are not) _____ required in commercial garage areas, with in the horizontal and _____ boundaries of the defined hazardous areas.
5. List 6 types of wiring methods which may be used above hazardous areas:
 - a. _____
 - b. _____
 - c. _____
 - d. _____
 - e. _____
 - f. _____
6. Receptacles in non-hazardous areas shall be of _____ type.
7. Battery _____ equipment shall not be located within the hazardous area.
8. Can electric vehicles be charged in a commercial storage garage?
Yes/No _____ Give the code section _____.
9. Flexible cords shall have:
 - a. Approval for _____ usage.
 - b. Adequate _____ for charging current.
 - c. Connector rating of no less than _____ amperes.
 - d. Connector will _____ readily at any position.
10. The entire hangar floor up to a level _____ inches above the floor is considered to be Class _____, Division _____ area.
11. The area 5'-0" above an aircraft wing is considered a Class _____ Division _____, area.
12. Any area within _____ feet of an aircraft is considered hazardous.

NAME _____

TEST C-4

13. All metallic raceways and non-current-carrying parts of fixed equipment or portable equipment regardless of voltage shall be _____.
14. Aircraft energizers shall have automatic controls to _____ the ground power unit electrically in case excessive _____ is generated.
15. Does portable mobile service equipment operate near aircraft which operates at a low voltage have to be grounded? _____ Give N. E. Code section for your answer. _____
16. What locations shall be included in the classifications?

17. Any area located within 20 feet of the gasoline dispenser area shall be classified Class _____, Division _____.
18. What classification of hazardous area extends to 18 inches above drive? _____
19. What are the classification and limits around the tank fill pipe?

20. Circuit breakers shall be capable of disconnecting all _____ conductors including the _____ simultaneously on circuits to dispensers.
21. Seals shall be installed in all conduits entering or leaving _____ pump or other enclosures located in Class _____, Division _____ or _____, when connecting conduit originates in a _____ - _____ location.
22. The first fitting in a dispenser after the conduit emerges from the concrete slab shall be a _____.
23. What electrical equipment must be grounded under this article?
 - a. _____
 - b. _____
 - c. _____
24. Does all underground wiring have to be in rigid metal conduit? _____ Give Code section for your answer. _____
25. The immediate area within _____ feet horizontally and vertically above the pump shall be classified as Class _____, Division _____.

NAME _____

TEST C-4

26. List restrictions and classification for an unventilated area containing a gasoline pump.
- a. _____
 - b. _____
 - c. _____
27. Underground plastic conduit or duct may be installed in a hazardous area of buried _____ feet or more below grade.
28. Buried raceways under defined hazardous areas shall be considered to be _____ the hazardous area.
29. What are the three main methods of applying finishes?
- a. _____
 - b. _____
 - c. _____
30. What are the hazardous substances involved in applying finishes?
- a. _____
 - b. _____
 - c. _____
 - d. _____
 - e. _____
 - f. _____
31. The hazardous classification of Class _____, Division _____, covers areas within _____ feet horizontally of paint spray booths.
32. The hazardous classification of Class _____, Division _____, covers areas within _____ feet horizontally of dip tank and their drain boards.
33. The hazardous classification of Class _____, Division _____, covers the area beyond the limits of Class I, Division 1, around paint spray booths and dip tanks.
34. What two requirements must be met for an area utilizing drying, curing, or fusion apparatus to be classified as non-hazardous?
- a. _____
 - b. _____

NAME _____

TEST C-4

35. Give the five conditions which must be met to put a lighting fixture behind a panel of glass or other translucent material.

- a. _____
- b. _____
- c. _____
- d. _____
- e. _____

36. What four conditions will shut down an electrostatic spraying operation to prevent danger to the operator or a fire from starting?

- a. _____
- b. _____
- c. _____
- d. _____

37. Article 517 of the N. E. Code contains 10 parts. List them and what they cover.

- | | |
|----------|----------|
| a. _____ | f. _____ |
| b. _____ | g. _____ |
| c. _____ | h. _____ |
| d. _____ | i. _____ |
| e. _____ | j. _____ |

38. In a health care facility, what are the two main divisions of the emergency system?

- a. _____
- b. _____

39. What are the emergency system branches of a Nursing Home or Residential Custodial Care Facility?

- a. _____
- b. _____

40. Feeders and branches of the above emergency systems shall be _____ from all other wiring systems.

41. In patient care what are the minimum requirements for an equipment grounding conductor?

- a. Size _____
- b. Material _____
- c. Construction _____
- d. Installation _____
- e. Bonding _____

NAME _____

TEST C-4

42. Conduits in block walls in an anesthetics area are in a _____ area.
43. List three types of wiring permitted in a hazardous area.
- a. _____ c. _____
- b. _____
44. Each circuit shall be supplied from an _____ distribution system.
45. List three methods used for circuit isolation:
- a. _____ c. _____
- b. _____
46. Secondary voltage of an isolation transformer shall not exceed _____ volts.
47. Primary voltage to isolation transformer shall not exceed _____ volts.
48. Overcurrent _____ shall be installed in secondary neutral of isolation transformer.
49. Current through the ground indicator shall not exceed _____ -amperes.

NAME _____

DATE _____

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
THIRD YEAR - SERIES C
LESSON C-18 THRU C-23
TEST C - 5

1. A. Match Column B with Column A:

<u>Column A</u>	<u>Column B</u>
_____ 1. A requirement of service at constant load for an unlimited period.	a. Automatic
_____ 2. Basic functions are performed by hand.	b. Motor control
_____ 3. These items are used on large horsepower motors.	c. Manual controller
_____ 4. The type of control that is used when we have a magnetic starter on a push button "Stop-Start" switch controlling motor.	d. Semi-automatic
_____ 5. Controls eliminates the necessity of a manual control.	e. Continuous duty
_____ 6. Means the governing or regulating the functions of a motor or machine.	f. Compensators
_____ 7. What is the most popular manual controller.	g. Drum switch
	h. Full-voltage

B. Answer the following:

What is the purpose of a master switch?

What is the purpose of overload protection in a motor circuit?

Why are relays used?

How does a phase failure device operate?

NAME _____

TEST C-5

2. List two "methods of stopping" a motor.
 - a. _____
 - b. _____
3. How is phase-failure protection provided? _____

4. When does single phase occur in a three-phase motor? _____

5. What type pilot devices provide an under-voltage protection?

6. List three means of short-circuit protection.
 - a. _____ c. _____
 - b. _____
7. Interlock in a starter may be accomplished by _____ or
_____ connection.
8. What is the most popular starter used? _____

9. List the six main components of an automatic synchronous motor starter:
 - a. _____ d. _____
 - b. _____ e. _____
 - c. _____ f. _____
10. The most critical component in a synchronous motor starter is the
_____ - _____ relay.
11. List seven main components of a semi-automatic synchronous motor
starter:
 - a. _____ e. _____
 - b. _____ f. _____
 - c. _____ g. _____
 - d. _____

NAME _____

TEST C-5

12. List the five main components of a wound-rotor motor starter:

- | | |
|----------|----------|
| a. _____ | d. _____ |
| b. _____ | e. _____ |
| c. _____ | |

13. A relay _____ requires a low current for functioning and may be used to _____ circuits of larger currents.

14. List five types of relays:

- | | |
|----------|----------|
| a. _____ | d. _____ |
| b. _____ | e. _____ |
| c. _____ | |

15. List three types of overload relays:

- | | |
|----------|----------|
| a. _____ | c. _____ |
| b. _____ | |

16. Thermal relays trip on heat and are called _____ relays.

17. A _____ motor starter closes the line contacts magnetically.

18. Magnetic starters for multispeed motors must have a _____ for each speed.

19. Motor-control circuit components may be classified as _____ devices or _____ devices.

20. Pilot control devices _____ or _____ primary control devices.

21. A magnetic starter is a _____ device.

22. List four types of pilot devices:

- | | |
|----------|----------|
| a. _____ | c. _____ |
| b. _____ | d. _____ |

23. Overload _____ are pilot devices.

24. Pilot _____ are sensing devices.

NAME _____

TEST C-5

25. List three types of thermostats:
- a. _____ c. _____
b. _____
26. Push-_____ is most commonly used pilot devices in motor-control circuits.
27. List two types of push-button stations:
- a. _____ d. _____
28. Maintained-contact type push button operates motor-control by _____.
29. Momentary contact type push button operates motor-control _____.
30. The _____ is the written language of control circuits.
31. List three general types of control diagrams:
- a. _____ c. _____
b. _____
32. A _____ diagram is best suited drawing for making initial connections of a _____.
33. A _____ is easiest drawing to understand.
34. What is the chief advantage of the wiring diagram? _____
35. "Start" push buttons or components are connected in _____.
36. "Stop" push buttons or components are connected in _____.
37. How are control circuits developed? _____
38. List two basic types of control circuits:
- a. _____ b. _____

NAME _____

TEST C-5

39. Push buttons which are used on three-wire control circuits are called _____ - _____.
40. Push buttons which are used on two-wire control circuits are called _____ - _____.
41. Momentary-contacts control circuits provide _____ - _____.